

LETTER  
FROM  
THE SECRETARY OF WAR,

IN RESPONSE TO

*Senate resolution, January 25, 1886, relative to appropriation for breakwater at Port Orford, Oregon.*

FEBRUARY 8, 1886.—Ordered to be printed and referred to the Committee on Commerce. The accompanying papers referred to the Committee on Printing.

APRIL 1, 1886.—Accompanying papers ordered to be printed.

WAR DEPARTMENT,  
*Washington City, February 4, 1886.*

The Secretary has the honor to transmit to the United States Senate a letter of the 1st instant from the Chief of Engineers, and the accompanying copy of Appendix P P of his Annual Report for 1881, the same being transmitted in response to a resolution of the Senate of the 25th ultimo, as follows:

*Resolved*, That the Secretary of War be, and he is hereby, directed to report to the Senate what disposition, if any, has been made of the one hundred and fifty thousand dollars appropriated by Congress for the commencement of the construction of a breakwater at Port Orford, Oregon, by the act approved March third, eighteen hundred and seventy-nine.

WM. C. ENDICOTT,  
*Secretary of War.*

THE PRESIDENT PRO TEMPORE, UNITED STATES SENATE.

OFFICE OF THE CHIEF OF ENGINEERS,  
UNITED STATES ARMY,  
*Washington, D. C., February 1, 1886.*

SIR: I have the honor to acknowledge the reference to this office of the resolution of the Senate of the United States dated January 25, 1886, directing the Secretary of War "to report to the Senate what disposition, if any, has been made of the one hundred and fifty thousand dollars appropriated by Congress for the commencement of the construction of a breakwater at Port Orford, Oregon, by the act approved March three, eighteen hundred and seventy-nine."

The river and harbor act of March 3, 1879, provides (U. S. Stat. at Large, vol. 20, p. 372)—

That the sum of one hundred and fifty thousand dollars be, and the same is hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, to be expended by the Secretary of War in the commencement of the construction of a breakwater and harbor of refuge at such points on the Pacific Ocean between the Straits of Fuca and San Francisco, California, as may, in the opinion of a majority of the Board of United States Engineers for the Pacific Coast, be most suitable, the interests of commerce, local and general, being considered.

With the sanction of the Secretary of War the selection of the site for the projected harbor was referred to the Board of Engineers for the Pacific Coast, as required by the law, and in order that the Board might be enabled to give full consideration to the subject, which is of great importance to the commercial and navigation interests of the Pacific Coast, it was recommended that so much of the appropriation for the commencement of the harbor as might be required for the necessary examinations and surveys, be made available for that purpose.

This recommendation having received the approval of the Secretary, the Board was instructed accordingly, and under date March 6, 1880, submitted its report, which was transmitted to the Senate and printed as Ex. Doc. 188, Forty-sixth Congress, second session. The majority of the Board designated Port Orford as the most suitable point for a harbor of refuge.

Under date January 15, 1881, the Board of Engineers submitted a supplementary report, which was, in compliance with a resolution of the Senate of February 19, 1881, transmitted to that body and printed as Senate Ex. Doc. No. 59, Forty-sixth Congress, third session. In this report the majority of the Board adhered "to its former selection of Port Orford as the point most suitable for a harbor of refuge, the interests of commerce, local and general, being considered."

A copy of Appendix P P of the Annual Report of the Chief of Engineers for 1881, which contains a full history of the investigations of the Board in connection with the subject of harbors of refuge on the Pacific coast, is herewith submitted.

The sum of \$8,626.92 from the appropriation of March 3, 1879, was expended by the Board of Engineers in its surveys and investigations, and no disposition has been made of the balance (\$141,373.08) for the reason stated in the Report of the Chief of Engineers for 1881, as follows:

It may be well to state that according to the estimates of the Board an ultimate expenditure of about \$8,000,000 will be involved in the complete establishment of the harbor in question. As it is evident that the expenditure of the amount now available cannot produce any beneficial results, it is proposed to withhold it till a further appropriation is made. This course will be in the interests of economy, and will not delay the final construction of the harbor.

The resolution of the Senate is herewith returned.

Very respectfully, your obedient servant,

JOHN NEWTON,  
*Chief of Engineers,  
Brig. and Bvt. Maj. Gen.*

Hon. WM. C. ENDICOTT,  
*Secretary of War.*



[Extract from the Annual Report of the Chief of Engineers to the Secretary of War.]

OFFICE OF THE CHIEF OF ENGINEERS,  
UNITED STATES ARMY,  
*Washington, D. C., October 22, 1881.*

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HARBOR OF REFUGE ON THE PACIFIC COAST.

The river and harbor act of March 3, 1879, appropriates \$150,000 to be expended by the Secretary of War in the commencement of the construction of a breakwater and harbor of refuge at such point on the Pacific Ocean between the Straits of Fuca and San Francisco, Cal., as may, in the opinion of a majority of the Board of United States Engineers for the Pacific Coast, be most suitable, the interest of commerce, local and general, being considered.

To comply with a resolution of the Senate of May 5, 1880, a majority and a minority report of the Board of Engineers, dated March 6, 1880, was transmitted to the Senate May 8, 1880, and printed as Senate Ex. Doc. No. 188, Forty-sixth Congress, second session; and on May 24 there was also transmitted to Congress as an appendix to the above a letter from Assistant George Davidson, United States Coast and Geodetic Survey, in reply to a request from the Board asking the results of his observations and experience on the coast. As the selection of a site had been made by the Board before the receipt of this communication, it formed no part of the proceedings previously had. This letter was printed as Part 2 of the above Congressional document. Subsequently, on June 3, another communication was received upon the same subject, also at the request of the Board, from Assistant A. F. Rodgers, of the United States Coast and Geodetic Survey. The Board also invited, by public notice in the journals of the coast, all persons who so desired to submit their views, either verbally or by letter.

As some of these communications were not received by the Board in time for consideration before its report on the location of the harbor of refuge was made, and in view of the magnitude of the work, the importance of the fullest discussion of the subject, and of the diversity of opinion which appeared to exist, in some instances at variance with the views of the majority of the Board, with the sanction of the Secretary of War instructions were given to the Board to reconsider the whole subject.

The Board accordingly, after further consideration, submitted its supplementary report, January 15, 1881, which was transmitted to the Senate in compliance with its resolution of February 19, and is printed as Senate Ex. Doc. No. 59, Forty-sixth Congress, third session.

It will be seen that this report is not a unanimous one; that the majority of the Board, having studied and carefully examined the papers before it and reconsidered the whole subject, sees no reason for changing the views expressed in its report of March 6, 1880, that Port Orford is the most suitable point for the proposed harbor of refuge.

It will also appear that the dissenting member adheres to his previously expressed opinion that Trinidad presents greater advantages than any other point, and reserves the right to present a full expression of his views at a later period.

It may be well to state that according to the estimates of the Board

an ultimate expenditure of about \$8,000,000 will be involved in the complete establishment of the harbor in question. As it is evident that the expenditure of the amount now available cannot produce any beneficial results, it is proposed to withhold it till a further appropriation is made. This course will be in the interest of economy, and will not delay the final construction of the harbor.

(See Appendix P P.)

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## APPENDIX P P.

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### PROPOSED HARBOR OF REFUGE ON THE PACIFIC OCEAN, BETWEEN THE STRAITS OF FUCA AND SAN FRANCISCO, CALIFORNIA.

OFFICE OF THE CHIEF OF ENGINEERS,  
UNITED STATES ARMY,  
*Washington, D. C., May 7, 1880.*

SIR: I have the honor to acknowledge the reference to this office, on the 6th instant, of the resolution of the Senate of the United States of the 5th instant directing the Secretary of War—

To furnish the Senate with a copy of the majority and minority reports of the Board of Engineers on the proposed harbor of refuge on the Pacific Coast, and, in obedience to its requirements, to submit the inclosed copies of the reports referred to.

It may be proper to state that the reports in question were made to comply with the following provision of the river and harbor act of March 3, 1879:

That the sum of one hundred and fifty thousand dollars be, and the same is hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, to be expended by the Secretary of War in the commencement of the construction of a breakwater and harbor of refuge at such point on the Pacific Ocean, between the Straits of Fuca and San Francisco, California, as may, in the opinion of a majority of the Board of United States Engineers for the Pacific Coast, be most suitable, the interests of commerce, local and general, being considered.

I have also the honor to inclose a letter from the senior member of the Board of Engineers for the Pacific Coast, dated April 21, 1880, in relation to the minority report referred to.

Very respectfully, your obedient servant,

H. G. WRIGHT,  
*Chief of Engineers,  
Brig. and Bvt. Maj. Gen.*

Hon. ALEXANDER RAMSEY,  
*Secretary of War.*

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### REPORT OF BOARD OF ENGINEERS FOR THE PACIFIC COAST.

OFFICE OF THE BOARD OF ENGINEERS PACIFIC COAST,  
*San Francisco, Cal., March 6, 1880.*

GENERAL: The Board of Engineers for the Pacific Coast has the honor to submit the following report in the matter of the selection of a site for a harbor of refuge on the Pacific Coast, between San Francisco and the Straits of San Juan de Fuca, referred to the Board for decision by the river and harbor act of March 3, 1879.

The majority of the Board designates Port Orford as the most suitable point for a harbor of refuge.

## CHAPTER I.

## INTRODUCTION.

The river and harbor act of March 3, 1879, provides as follows :

That the sum of one hundred and fifty thousand dollars be, and the same is hereby, appropriated, out of any moneys in the Treasury not otherwise appropriated, to be expended by the Secretary of War in the commencement of the construction of a breakwater and harbor of refuge at such point on the Pacific Ocean, between the Straits of Fuca and San Francisco, California, as may, in the opinion of a majority of the Board of United States Engineers for the Pacific Coast, be most suitable, the interests of commerce, local and general, being considered.

EXTRACT OF LETTER OF CHIEF OF ENGINEERS TO THE SECRETARY OF WAR, DATED WASHINGTON, D. C., APRIL 11, 1879.

It is proposed, with your sanction, to refer the selection of the site for the projected harbor to the Board of Engineers for the Pacific Coast, as required by the above item; and in order that the Board may be enabled to give full consideration to this subject, which is one of great importance to the commercial and navigation interests of the Pacific Coast, I beg to recommend that so much of the appropriation for commencement of the harbor as may be required for the necessary examinations and surveys be made available, and that the Board be instructed to submit an estimate of the sum that will be required for the purpose of selecting a suitable site for the harbor and the preparation of a project, with estimate of cost.

Owing to the recent death of Lieut. Col. B. S. Alexander, Lieut. Col. C. S. Stewart has become the presiding officer of the Board of Engineers for the Pacific Coast, with Lieut. Col. R. S. Williamson and Maj. G. H. Mendell, Corps of Engineers, as his associates. With your sanction Maj. G. L. Gillespie, Corps of Engineers, who is in charge of harbor and river improvements in Oregon, will be added to the Board.

Very respectfully, your obedient servant,

H. G. WRIGHT,  
*Acting Chief of Engineers.*

[First indorsement.]

The recommendations of the Chief of Engineers are approved.  
By order of the Secretary of War.

H. T. CROSBY,  
*Chief Clerk.*

WAR DEPARTMENT, *April 18, 1879.*

The inquiry thus devolved upon the Board of Engineers for the Pacific Coast is not before it for the first time.

In February, 1877, the Board, after a personal examination of the coast, submitted a report upon the most suitable position for a harbor of refuge, which is published in the report of Chief of Engineers for 1877, Appendix J J.

The location preferred by the Board was Trinidad, for which point, among others, a plan and estimate were prepared. Several possible sites for a harbor of refuge have at various times been examined and reported upon by different officers of the Corps of Engineers.

Port Orford was the subject of a careful examination and report by Maj. H. M. Robert, in January, 1873, published in report of Chief of Engineers for same year, Appendix Y 5. Maj. John M. Wilson, in 1878, made a second examination of and report upon this roadstead.

Lieutenant-Colonel Williamson made a report on Crescent City in July, 1867, published in report of Chief of Engineers of the same year.

Lieutenant-Colonel Stewart made a report on Trinidad September 25, 1872, published in Appendix Z, report of Chief of Engineers, 1873.

Maj. J. M. Wilson made a report on Cape Foulweather in 1878.

These various studies of the subject of a suitable site for a harbor of

refuge, together with the acquaintance of many years with the coast and its meteorology on the part of the members of the Board, led to the conclusion that the proper site must be looked for to the northward of Cape Mendocino. This conclusion is confirmed by the general, if not unanimous, opinions of the shipmasters examined before the Board.

Another opinion held by the Board had a determining influence upon its operations, and limited the number of points to be examined. This opinion was to this effect namely, that no harbor which is obstructed at its entrance by a bar having a depth much less than that found on the San Francisco bar could in that condition of depth be regarded as a harbor of refuge. The reason for this opinion is, that such a harbor would be inaccessible on account of breakers at the very time it was needed. The force of this objection becomes much stronger as we proceed north from Cape Mendocino, for the reason that it is well established by testimony, as will be seen hereafter, that the storms from which vessels need refuge are more frequent, more violent, and more prolonged until we reach nearly the latitude of Washington Territory, along which coast these maxima are maintained.

The Board is also of the opinion that the probabilities of securing a sufficient and permanent increase of depth on the bars of these harbors by means of such engineering constructions as would obviate the objection of inaccessibility do not justify the Board in considering bar harbors as possible refuges.

The effect of these preliminary conclusions of the Board was to limit their personal examinations to points between Cape Mendocino and the Columbia River, because to the north of the Columbia and south of the Straits of Fuca there are but two harbors or places that can be made harbors, namely, Shoalwater Bay and Gray's Harbor, and both of these have bars at their entrance exposed to the heaviest seas.

By the same principle several places lying between Cape Mendocino and the Columbia River were excluded from examination. Among these may be mentioned Humboldt, Coos Bay, and Umpqua. Of these the Board examined only Coos Bay, and this, not for the reason that it was deemed a suitable site, but for a double and different purpose, namely, in search of stone that could be used at Cape Gregory, in case that site should be approved; and, secondly, in examining the conditions of the location and proper construction of a jetty for the improvement of the entrance, a subject which had been referred to the Board for decision.

Among the earliest points which engaged the attention of the Board in its preliminary arrangements was the best means of meeting and satisfying the great popular interest with which the subject is invested, and at the same time of eliciting the opinions of mariners generally, and particularly of those having experience on the Pacific coast. The members of the Board, being without nautical experience, felt the need of the technical and practical knowledge of the sailor, in order to feel sure that conclusions might not violate the necessities of the nautical art.

It was felt that possibly in some way very important knowledge not a matter of record might be brought out to aid the judgment of the Board.

In order to secure these desirable ends, the Board thought fit to invite, by public notice in the journals of the coast, all persons who desired to express their views to appear before the Board in its public sessions and submit their opinions in the way most agreeable to themselves, either verbally or by letter. In accordance with this determination, a number of public sessions were held, mainly at San Francisco, during which



forty-two persons gave evidence. Their statements were recorded by a stenographer. Special invitations were sent to a number of persons in the naval, revenue, merchant, and Coast Survey Service, and to the board of underwriters of this city, asking for an expression of opinion. The opinions which were elicited in these various ways, whether verbal or in writing, accompany this report as appendices.

As another important source of information the Board has been in possession of maps of Coast Survey of Trinidad, Crescent City, Port Orford, Mack's Arch, and a general chart of the coast. These charts give the outline of the shore-line of the harbors and approaches, the positions of dangers so far as they have been ascertained, the depth of water in the harbors and approaches, and the rise of the tides. In the case of Trinidad the off shore soundings are given.

There is no Coast Survey chart of the anchorage under Cape Gregory. In order to supply this want, and, in addition, to acquire a knowledge of the physical circumstances affecting the suitability of this point as a harbor of refuge, the Board caused a survey and study of this locality to be made.

The Board also thought it proper to verify the Coast Survey soundings in Port Orford along probable lines of construction. This was not done out of distrust of the official charts, but was thought to be justified by the expensive character of any construction that could be projected for this point. It may be stated that the result of these soundings was in general agreement with the published charts. The duties thus outlined were performed in a very intelligent manner by the recorder of the Board, First Lieutenant Payson, of the Corps. (Appendix D.\*)

An instrumental survey of the entrance to Yaquina Bay and an examination and soundings of the bar were made by Mr. George W. Wood, under the direction of the Board. (Appendix E.\*)

The Board also made a personal examination of each of the points under consideration, spending a day or two at each point for the purposes of seeing the local features in each case, ascertaining the local character and quantity of material, the facilities and general arrangements possible for construction, testing the character of the bottom, and finally, in order to meet the principal inhabitants at each port and listen to whatever arguments or information they were disposed to lay before the Board.

The narrative of this voyage, which occupied fourteen days, from July 17 to August 1, will be found further on in this report.

A collection of the facts of the principal marine disasters which have occurred on the Pacific coast in the past five years was also made and is appended.\*

This statement gives the time, place, circumstances, and extent of each disaster, and throws some light on the probable influence of a harbor of refuge on the safety of vessels. This statement is prepared from the records of the custom-house of this city.

Tables of trade, showing imports, exports, character and number of vessels, and money values, have been procured, as far as possible, for various points, and are also appended.\*

The foregoing is an outline of the method and extent of the inquiry pursued by the Board. This inquiry seems to the Board to embrace all sources of information open to it or practicable during an investigation of a few months.

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\* Omitted. All parts herein marked as omitted will be found printed in Senate Ex. Doc. 188, Forty-sixth Congress, second session.

The general physical facts affecting the choice of a harbor of refuge are probably as well known now as they ever will be. The shore-lines and the course and occurrence of the storms are well known. Each year probably adds some knowledge of detail to previous information, but it will be a long time, if ever, before this kind of information can greatly modify the influence of the main controlling facts. The commercial facts are, however, open to change. A great increase of commerce must flow to and from the extensive and productive country of the Northwest. This change may in time, by its method and by its amount, assume the dimensions of a revolution.

#### NARRATIVE OF VOYAGE.

Upon the termination of the public sessions held in this city, the members of the Board proceeded to make a personal examination of the coast north of San Francisco and to visit those harbors to which their attention had been specially called as most suitable for the site of the breakwater and harbor of refuge. For this purpose they left San Francisco in the steamer *Constantine* on the 17th of July. The course of the steamer, for reasons already stated, was so directed that only such an examination was made of Drake's Bay and the coast south of Cape Mendocino as was possible from her deck. She arrived at Trinidad early in the morning of the 19th. The Board landed, and passed the day in making an examination of Trinidad Head and its vicinity and of the shore in the neighborhood of the outlet to Little River, some 3 or 4 miles below the head. Soundings were made in the bay, and specimens of the bottom procured. From residents of the place of long standing other information of value was obtained.

During the night the vessel proceeded to Crescent City, reaching that town on the 20th. In company with prominent citizens, the remainder of the day and the 21st were occupied in visiting the beach and various points where it was thought suitable stone might be found for the construction of a breakwater and in inquiring into the resources of the neighborhood. An investigation into the extent of a large shoal in the harbor and into the character of the bottom was made. Soundings were also taken at various points.

On the 22d, continuing up the coast, we entered Chetko Cove, just north of the Oregon line. After remaining there a short time without landing, it being a place of no commercial importance at present, and the morning being foggy, the steamer continued on her course to Mack's Arch, reaching it before noon. She anchored in the northwest shelter formed by the rocks and ledges here, but owing to the violence of the wind and sea no landing was made until the 23d. Then, upon examination, a good quality of sandstone was found upon the shore, but, from appearances, it would be difficult to get it out in large quantities.

No soundings could be made along the reef owing to the strength of the wind and the heavy swell, but a few specimens of the bottom were obtained.

About midnight the steamer got under way, and early on the morning of the 24th anchored at Port Orford. Here the members of the Board landed, and inspected the rocky heads and the country back of the roadstead.

The character of the bottom was tried at various points, and some soundings were made. After obtaining such information as could be had, we proceeded, on the morning of the 25th, to Cape Gregory or Arago.

Owing to the prevalence of fog, it was impossible for the tug to come out of Coos Bay to pilot us in. The steamer anchored close in by the light-house on the cape, and we landed on this rocky islet. The rock of which it is chiefly composed is a very soft and inferior sandstone, which is in places wearing away very rapidly, and is unfit for a construction exposed to the action of the sea.

Upon returning to the steamer, leaving the cape, owing to the continuation of the fog, she anchored near the bar buoy until the 26th. During that day a tug came out from Coos Bay and piloted her over the bar to Empire City.

A delegation of citizens from various towns in the south of Oregon met the Board, and the 27th and 28th were spent in accompanying them to different parts of the bay and sloughs and to Coos River in search of stone suitable for the construction of a breakwater, and also in an inspection of the coal mines and other visible resources of this region.

Late in the afternoon of the 28th the steamer crossed the bar and anchored the next morning near Foulweather light, under the south side of the head. After landing and examining the cape and the cove on the north side, the Board went by land to the outlet of Yaquina Bay, nearly 4 miles to the south of Foulweather, and gave the rest of the day to an exploration of the bay and to an inspection from the north head of the approaches and of the entrance.

Getting under way during the night, the vessel arrived at Astoria about noon of the 30th. At the suggestion of a delegation of the citizens of that town, a public session of the Board was held at the custom-house, where several pilots, long familiar with this coast, gave their views on the subject of a harbor of refuge. On the 31st the Board proceeded to Portland. A committee of the board of trade of that city was present at a public session there, on the 1st of August, and presented its views as to the mouth of the Columbia River in connection with a harbor of refuge.

Upon the completion of their duties in that city, the members of the Board returned to their several stations.

## CHAPTER II.

### DESCRIPTION OF THE NORTH PACIFIC COAST.

The stretch of coast proposed by the act of Congress for our consideration extends from San Francisco to the Straits of Fuca, from latitude  $37^{\circ} 49'$  to  $48^{\circ} 23'$ ; from longitude  $122^{\circ} 30'$  to  $124^{\circ} 44'$ . The length of shore-line between these points is 950 statute miles. The length measured by the most direct line between the points is 750 miles.

The coast, as a whole, is remarkable for its boldness of outline and continuity, unbroken by deep bays or large estuaries. The bights are long and narrow.

Beginning at Point Boneta, the north head of San Francisco Harbor, the lengths of bights measured from headland to headland and the recession of the shore-line in each bight from this line are successively as follows:

Point Boneta to Point Reyes, magnetic course W. by N., distance 30 miles, greatest depth of bight 5 miles; Point Reyes to Point Arena,

course NW., 77 miles, depth of bight 11 miles; Point Arena to Point Gorda, NW. by N., 93 miles, depth of bight 16 miles; Point Gorda to Cape Mendocino, NW. by N.  $\frac{1}{2}$  N., distance 12 miles, depth 2 miles; Cape Mendocino to Cape Blanco, NNW., 167 miles, depth of bight 21 miles; Cape Blanco to Cape Disappointment, N. by W., 235 miles, depth of bight 11 miles; Cape Disappointment to the point near Quilleyute Rock, NW.  $\frac{3}{4}$  N., 120 miles, depth of bight 9 miles; thence to Cape Flattery, or Straits of Fuca, NNW., 28 miles, depth of bight 2 miles.

South of Cape Blanco, in the southern half of the coast-line, the main as well as the minor indentations are much more marked and more numerous than they are in the northern half of the coast length. The coast of Oregon, north of Blanco and Washington, is indeed remarkably straight in alignment.

Starting from the north head of San Francisco, the coast is bold and high to Point Reyes, which is a high promontory, precipitous to the sea and extending well to the west of the land between it and San Francisco. The effect of this topography is to produce a fine shelter from northerly winds under its lee. This anchorage is known as Drake's Bay.

North of Point Reyes the coast falls in altitude, but is characterized for almost the whole distance to Point Arena by the boldness of shore outline.

North of Point Arena it begins to rise to very considerable altitudes, reaching a height of several thousand feet close behind Cape Mendocino. A few miles north of the cape the boldness of the shore is varied by a low sand-spit which separates Humboldt Bay from the Pacific Ocean. Leaving this low-lying land, which is 12 or 15 miles in length, the high coast returns and is maintained to Trinidad, thence to Crescent City and to Port Orford, and past it to Cape Blanco, with here and there a small stretch of low coast.

The general features of the coast north of Cape Mendocino are thus described in the Coast Pilot, edition of 1869:

From Cape Mendocino the hills on the sea-board range from two to three thousand feet high, running parallel with the coast at a distance of 3 to 5 miles, receding somewhat at Eel River and Point Saint George, and at (some) other points coming abruptly to the ocean. The whole face of the country is covered with dense forests and offers almost insurmountable obstacles to the opening of roads intended to strike the trail leading along the valleys of the Sacramento and Willamette.

Northward of Cape Orford (Blanco) the appearance and nature of the coast assume a marked change. Long reaches of low, white sand occur, with sand dunes, broken by bold, rocky headlands, and backed by high, irregular ridges of mountains. The general altitude of the mountains appears the same as to the southward.

The principal reaches of sand on this coast, counting from Cape Orford, are 17 miles to the mouth of the Coquille, where a headland comes to the sea; then 10 miles more of sand to the southern point of Cape Gregory, which is a bold shore as far as Coos Head; thence sand again for 22 miles, as far north as the Umpqua and for 2 miles beyond the Umpqua. Here comes in a stretch of bold, rocky coast 8 miles in length, and then 15 miles of sand dunes to Cape Perpetua.

Various other stretches of sand occur at intervals until Tillamook Headland is approached. Here a long sand-beach extends northward for 100 miles, broken by the entrance of the Columbia River and the headland of Cape Disappointment. Beyond this to Cape Flattery, at the entrance of the Straits of Fuca, the coast is again bold, high, and rocky, with occasional stretches of sand. Within this length of sand, to the north of the Columbia, are the estuaries of Shoalwater Bay and of Gray's Harbor.



There are, then, two characteristics which may be said to distinguish the coast north of Cape Blanco from that to the southward: The first is the straightness of the alignment, and the second is the prevalence of sand. Indeed, the latter feature seems capable of accounting for the first. The considerable bay that once existed at the mouth of the Columbia River, bounded on the north by Cape Disappointment, on the south by Tillamook Head, with a bight as far inland as Smith's Point at Astoria, has been converted into a straight coast by the development of the sand-plains extending northward from Tillamook to Point Adams. A similar straightening of the coast seems to have taken place in the development of the long sands-pit extending south from Umpqua to Cape Gregory, which separates Coos Bay from the ocean.

The following remarks occur in the report on Coos Bay made by First Lieutenant Payson:

An examination of the coast north of Coos Head furnishes ample evidence of a large movement of the sand southward; under the influence of the summer northwest winds, which, though not equal in violence to the winter gales in the opposite direction, are yet so steady during most of the year that their effect is much the more important one.

The dunes back of the beach, some of which are 150 feet in height, show this movement in their form, with sharp slopes to leeward, and from the crest of each on any summer day may be seen blown out a long trail of flying sand.

Large tracts to the north of Coos Bay and along the neck separating its lower part from the sea, where once stood farms and pine forests, are now buried to the tops of the highest trees. Immense quantities of this wind-borne sand are constantly going into the bay, and by its swift currents carried out to form the bar or be deposited in the bight to the east and north of the cape.

The sand-dunes appear to connect the rocky headlands in lines that are nearly straight. The entrances to harbors and rivers all along this coast are bounded on one side by a high, rocky headland, and on the other by a tongue of sand-dunes, which, by reason of the winds and currents, is more or less unstable. Coos Bay, Tillamook Bay, Umpqua River, and Columbia River are all instances of this. The rocky headland is sometimes on the north, as at Columbia River, and on the south, as at Coos Bay. The tongues of sand have therefore their free ends sometimes to the north and sometimes to the south. The summer winds, which are generally from the northwest, seem to be an agency sufficient to account for the latter.

The influence which inshore currents may exercise in these developments has not, so far as we are aware, been noted.

The geological age of the coast is tertiary or late secondary. The stone is almost everywhere sandstone, generally metamorphic. At Cape Gregory the sandstone is unchanged. Granite appears underlying the sandstone at Point Reyes. The Farallone Islands are granite. Granite is not found at any other points on this stretch of coast so far as is known. At Cape Foulweather basalt makes its appearance in considerable quantities, doubtless overlying the sandstones.

The sandstone has not been exposed in quarries; it seems, however, to present the same general lithological features as may be observed in California. It has about the same specific gravity, which is from 2.6 to 2.7. It is also similar, as far as it can be observed, to the California stone in having many planes of division which are likely to prevent a large proportion of big stones being obtained in quarrying.

#### REEFS.

It is also important to notice that several of the bold headlands of the coast have reefs extending several miles off shore. This is an important feature both at Cape Mendocino and at Cape Blanco, for the reason



that at these points coasting steamers change their course to conform to the variations in the trend of the shore.

Port Orford Reef, just to the southward of Cape Blanco, is a group of rocky islets with some sunken dangers. It is  $2\frac{1}{2}$  miles long and  $1\frac{1}{4}$  miles wide, the largest dimension being from north to south. The southern end is 5 miles northwest from the headland of Port Orford. The reef lies nearly parallel to the coast and 3 miles off. Between it and the coast is a quite straight channel of 10 fathoms,  $1\frac{1}{2}$  miles wide, which is often used by steamers. One of the worst rocks is Fox Rock, which is to the southwestward of the main body of the reef, nearly  $1\frac{1}{2}$  miles off. It is a small rock just awash. With this exception the west side of the reef shows no danger.

The reef itself is in clear weather easily recognized by the high rocky islets. Steamers have sometimes passed through the reef itself.

Blunt's Reef lies 3 miles off Cape Mendocino, with foul ground between it and the cape. Formerly the coasting steamers were in the habit of passing between the reef and the cape, but since the loss of the *Northerner*, which occurred twenty years ago, and was due to striking a sunken rock in its passage, it has been the rule to keep outside the reef.

Lying between these two is another reef, off Point Saint George, commonly called the Crescent City Reef, from the fact that Crescent City is near to the southward and eastward. The reef extends 6 miles west-northwest of Point Saint George, and consists of a number of bold rocks standing high out of the water with a number of sunken rocks. There is a passage through this reef a mile in width, having a depth of 10 fathoms. The reef, as a whole, is well marked and easily distinguished in clear weather.

The Rogue River Reef lies near the mouth of the river of the same name. It is 14 miles south of Port Orford, and is to be guarded against by a vessel approaching this point, following the coast. It stands out 4 miles from the coast. It is composed of high, bold rocks, with some hidden dangers, and a dangerous channel through it.

Just north of Trinidad and well inshore lies a reef called the Turtles, and still further north, half way between Trinidad and Crescent City, is Redding Rock, a bold, rocky islet, 5 miles from land, with no hidden dangers.

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## CHAPTER III.

### HARBORS AND PORTS ON THE NORTH PACIFIC COAST.

Different parts of this extended coast-line are also distinguished by differences of trend in regard to the points of the compass. The total westing from Point Boneta, the north head of San Francisco, to Cape Flattery, is  $2^{\circ} 13'$ . Of this total  $1^{\circ} 54'$  is made in going from Point Boneta to Cape Mendocino, in a northing of  $3^{\circ} 37'$ , and a length of shore-line of 250 miles. The remaining northing to the Straits of Fuca,  $7^{\circ} 57'$ , gives a westing of only  $17'$ . Counting from Cape Blanco to Tatoosh Island, off Cape Flattery, a distance in latitude of  $5^{\circ} 33'$ , the westing is  $13'$ .

This trend of the southern coast to the west, below Cape Mendocino, accounts for the number of safe anchorages in summer or northwest

weather that are dotted along the shore-line so frequently. Each little westerly break in the coast-line gives some shelter in a limited space. This belt of coast is well timbered with redwood, and these facts together account for the very considerable fleet of small schooners which the commercial statistics show to be employed in the commerce along this line. Redwood is not the only freight transported. In addition, there is considerable trade in dairy and agricultural products, which, however, is secondary to the lumber trade.

The following is a list of ports south of Cape Mendocino, thirty-nine in number: Shelter Cove, North Port, Rockport, Westport, Newport, Noyo River, Caspar Creek, Russian Gulch, Mendocino Bay, Little River, Big Gulch, Albion River, Salmon Creek, Novarro River, Cuffey's Cove, Uncle Abe's Landing, Bridgeport Chute, Point Arena Cove, Buster's Landing, Saunders' Chute, Rough-and-Ready, Hardscratch or Steen's Landing, Nip-and-Tuck, Fisk Rock, Collins' Landing, Bowen's Landing, Robinson's Landing, Bihler's Point, Stewart's Point or Fisherman's Bay, Fisk's Mills, Salt Point or Gerstle's Cove, Stillwater Cove, Timber Cove, Fort Ross, Rule's Landing, Bodega, Tomales, Drake's, and Bolinas Bays.

North of Cape Mendocino the open anchorages are less frequent and occur at longer intervals. Going north they are Trinidad, 40 miles north of the cape, Crescent City, Chetko, Mack's Arch, Port Orford, and Cape Foulweather, which all give good shelter from northerly winds and seas, but like all the other roadsteads heretofore mentioned are open to the south. The only exception to this southerly exposure is a small anchorage under Cape Gregory and close to the entrance to Coos Bay. Here the roadstead is protected from the south, and is open to northerly winds.

Owing to the topographical conditions which have been described, namely, to the high mountainous line that follows the coast, either closely or at most a few miles back, the rivers which drain the seaward slopes of the country are generally short and small, with rapid falls. Along the California coast there are no rivers of any considerable length. Eel River, which empties north of Cape Mendocino, has a practicable entrance for small vessels.

Next comes the Klamath, which enters the ocean in latitude  $41^{\circ} 33'$ . It has a bar and a variable channel, practicable for small vessels, and is navigable a few miles from its mouth.

Rogue River enters the ocean on the Oregon coast in latitude  $42^{\circ} 25'$ . It drains an extremely mountainous country. It has also a bad bar and a variable channel, practicable for small steamers.

The Coquille enters in latitude  $43^{\circ} 07'$ , 17 miles north of Cape Blanco. It is a good, deep channel inside; the bar, however, has only about 10 feet at low water, and is passable only in smooth weather by vessels of light draught.

The Umpqua is the largest stream that directly enters the Pacific Ocean on our coast south of the Columbia River. It rises in the Cascade Range of mountains, and, after draining a considerable valley in Central Oregon, breaks through the Coast Mountains and discharges into the Pacific Ocean in latitude  $43^{\circ} 42'$ , within the limits of the sand region already described. The channel over the bar is very variable, both in position and depth, shifting with each movement of the sands caused by the heavy waves. The usual depth on the bar at low water is 12 or 13 feet. The river is navigable for vessels that can cross the bar as far as Gardiner City, 5 miles, and for light-draught steamers to Scottsburg, 25 miles from the mouth.

Several small rivers enter the ocean between the Umpqua and the

Columbia. The Alseya and the Nehalem have shallow entrances practicable for light-draught vessels under favorable circumstances.

The Columbia River will be noticed further on.

There is still another class of harbors, not open roadsteads or river entrances, like those that have been described, but like the river entrances, in the characteristic that they are barred at the mouth by ridges of sand heaped up by the waves. This class comprises estuaries often of considerable area, in which the tide rises several feet. These estuaries communicate with the sea through a narrow channel having a low-water depth of 8, in some cases 14, feet over a bar of sand exposed to the full force of the heavy sea which prevails in southerly weather. The effect of this sea is oftentimes to make the bar impassable for days at a time.

It also often works great changes in the alignment of the channel and in its depth. These estuaries inside the bars generally have commodious channels with a depth of several fathoms.

The principal instances of this class of harbors are Humboldt Bay, in California, and Coos Bay, in Oregon. If we consider the depth and width of channel on the bars of these two harbors as due to the force of the ebb-tide alone, we could not but be surprised at the contracted character of these channels.

If we take San Diego Harbor as a type of the depth of entrance that a given tidal prism will produce, we should expect better channels both at Coos Bay and at Humboldt than either of them presents. San Diego has a stable channel, both in alignment and depth, which latter dimension is 21 feet. Coos Bay, with an equal and perhaps a larger tidal prism, has a depth of 13 or 14 feet, with, however, an exceptional and short-lived depth, at times of 20 or more feet. So at Humboldt, the channel has been at times  $3\frac{1}{2}$  and even 4 fathoms, changing suddenly to 10 or 12 feet.

The tidal prism is, then, not the determining influence on the normal dimensions of the channel. While without this prism there could be no channel, so without the heavy sea the channel might carry to the sea the depth of 6 or 8 fathoms, found inside. The sea alone, however, cannot make the great changes which occur on these bars. If the material to be moved by the sea did not exist in close proximity and in great abundance, these changes could not occur. The sea finds at hand unlimited quantities of sand and in its violence it piles it up in great masses, obstructs the channel, and hems in the tide of the estuary, which in time finds egress by a new route perhaps a half mile away. The action as it occurs at Coos Bay is well described by Lieutenant Payson, in his report upon this harbor.

At San Diego the seas are much less violent than they are on the northern coast, and it is perhaps due to this circumstance that a greater depth is there produced and maintained by a given tidal prism.

With regard to this class of harbors, it is a question whether they can be improved. The great difficulties are found in the circumstances that have been mentioned, namely, the presence of these immense masses of sand and the tremendous force of the sea. An attempt is now about to be made to so guide the tidal forces of Coos Bay as to give them a permanent direction, but it remains to be seen how far these forces can be made to resist the cumulating action of the sea on the sands about the entrance.

Other examples of these estuaries closed by bars are Yaquina Bay, 110 miles south of the Columbia River, and Shoalwater Bay and Gray's Harbor, north of the Columbia River. Both of the latter are situated within the great sand belt of this part of the coast.

## THE COLUMBIA RIVER.

There remains to notice the Columbia River, which has a bar at its mouth, over which the channel is not absolutely permanent, either in depth or direction. It is, however, notably distinguished from the other barred entrances, both by its greater normal depth and by the comparative slowness with which the cycle of change of channel is worked out.

In the bars that have thus far been noticed, a single storm has been able to shoal the channel several feet and shift its alignment a considerable distance—to such a degree, indeed, that previous knowledge of the channel would be simply a snare to a mariner attempting to either enter or leave, leading him to disaster.

The Columbia, on the other hand, works its changes slowly, and has never, within our acquaintance with it, shifted notably in one season. It has generally two entrances—the north and the south. The north channel, under Cape Disappointment, has generally been the best, and has been less subject to change. The south channel has, however, for the past twelve years been the channel generally used until recently. It has been for several years undergoing degradation. It now has a depth of about 18 or 19 feet at low water, while the north channel is about 22 or 23 feet in depth. A good tide running from 6 feet at neap to 9 feet at spring increases the effective depth very much.

The navigation of the bar channel is never interrupted except in southerly weather. During six or seven months of the year the channel is as free from difficulty as could be desired. At intervals during the remainder of the year, from November to April, during the prevalence of heavy southerly weather, and for a day or two succeeding this weather, the bar is rough, and at times impassable. In such a state of affairs a vessel may safely enter, when it would be dangerous to attempt an exit. Steamers have been delayed inside, waiting to get out, for a week. Delays of several days are liable to happen in any winter, but they rarely so happen to steamers making an entrance. Sailing vessels suffer more detention, particularly those drawing 20 feet of water or more. These vessels are generally taken in and out in tow.

This river is the outlet of the commerce of the growing and prosperous country drained by it and by its tributaries. The extent of this commerce as it exists to-day appears in the statistics accompanying the report.

The large immigration that continually goes into the unsettled districts of the Upper Columbia each year increases the productions and exports by this river. This area must for all time in the future be a very large factor in the wealth and prosperity of the Western coast.

The topographical conditions of the coast of Oregon force the commerce of the interior valleys for 200 miles and more south of the Columbia to seek an outlet by this river.

None of the harbors already mentioned to the south of the Columbia on the coast of Oregon have any good communications with the interior valleys. The high range of mountains that skirts the coast unbroken, except by the unnavigable rivers, the Umpqua and the Rogue, has thus far prevented any of the trade of the interior being done at the nearest points on the coast. This all now goes to Portland, and thence to the outer world by way of the Columbia River.

A good harbor at Coos Bay or Port Orford, with a good communication to the Umpqua and Rogue River valleys, is, then, for the whole central belt of country 200 miles north of the California line, a great



desideratum. The same conditions apply in the northern belt of California, north of the Humboldt. Indeed, for the whole distance between San Francisco and the Columbia River the interior country is at present debarred from communication with the world along a tolerably direct route.

The Columbia River is now a good harbor with certain limitations. It is not always accessible, but it is generally accessible, and always so in a couple days after the storm is past. It is, perhaps, possible to increase the measure of accessibility, and to some extent prove this point as a refuge. It is not, however, to be expected that this point could be made a refuge accessible at all times.

The exploring expedition found in 1841 a single channel over the bar straight to the westward, having a depth of  $4\frac{1}{2}$  fathoms. Clatsop Spit extended nearly west from Point Adams for a distance of 6 miles, and at its westerly point in 4 fathoms of water was 1 mile south of the same depth at the end of Peacock Spit, which ran south from Cape Disappointment for a length of 3 miles. This channel, 1 mile wide, had not less than 4 and as much as 9 fathoms of water. The bar was still farther to the west, being about 8 miles west of Point Adams. As compared with the present condition of the river, the bar was then much farther out and afforded much better water.

If any improvement of the mouth of the Columbia is attempted, it would seem to be desirable to restore as nearly as may be the condition of 1841.

#### SAN FRANCISCO AND STRAITS OF FUCA.

A short notice of the harbors that form the extremities of the long line of coast we have under consideration will complete this part of the report.

San Francisco, at the southern end of the line, is well known to be the commercial center of the Pacific coast. It has a capacious harbor, of all necessary depth, and one of the best entrances of any harbor in the world. The bar at its entrance carries 5 fathoms at low water, which the tide increases to 6 at high water. Close in under the north head is a narrow channel of 8 fathoms at low water. This channel can be used by steamers at all times. The main channel is occasionally impassable for a day at a time by reason of heavy breakers. This is, however, a rare circumstance.

The entrance to the Straits of Fuca is a wide, deep channel, without a bar. It is an inlet of the sea, leading to the quiet and extensive waters of Admiralty Inlet and Puget Sound. There are no breaking seas here to obstruct or delay an entrance. A strong ebb tide makes out of the straits, and the southeast wind, with which the great storms commence, blows out of the straits. With the tide and wind adverse, a sailing vessel would find it difficult, if not impossible, to enter. The tide, however, changes in a few hours, and the southeast wind always works to the west, and these changes make both the elements fair to a vessel seeking an entrance. Moreover, the coast of Vancouver Island, which bounds the straits on the north, is well indented with harbors.

Under these circumstances we must regard the northern end of this coast as well provided for refuge.

#### SUMMARY OF HARBOR ACCOMMODATION.

A general summary of the harbor accommodations along this coast, 700 miles, from San Francisco to the Straits of Fuca, may be made, as follows:

- 1st. That at each end of the line there is a harbor, approached by
- S. Ex. 63—2



deep, wide channels, which are practicable for entrance and exit, except very rarely and for very short intervals.

2d. That the Columbia River affords a good and always accessible harbor for all but the largest class of vessels during the summer months, but that frequently during half the year, the harbor entrance is, for short intervals and sometimes for considerable intervals, not free from danger.

3d. That between the Columbia River and San Francisco, 600 miles, there are a number of open roadsteads which afford good shelter against the summer winds, but none against the southerly winds, to which they are all open. The only exception is Cape Gregory, which affords imperfect and uncertain shelter.

4th. All the barred harbors in this stretch of the coast, whether they lie at the mouths of rivers or at the throats of estuaries, are inaccessible at all times for deep draught vessels, owing to want of depth, and in winter are often dangerous for vessels of small draught on account of the changes of channel and heavy seas.

#### CHARACTER OF HOLDING GROUND.

The beds of all the open roadsteads are of sand; some mud is found in nooks sheltered from the heavy southwest sea. A little mud was found close in the lee of Trinidad Head, but more clear of the head.

As nearly as we can ascertain, no mud is found anywhere on the coast in less than 15 or 20 fathoms, and as a rule the chart soundings of much greater depth show no mud. The heavy sea that breaks on the coast in winter probably clears the mud away. As a consequence, the holding ground in these ports is not generally good.

### CHAPTER IV.

#### THE STORMS OF THE NORTH PACIFIC OCEAN.

It is a notable characteristic of this long coast that it is not a lee shore. If it were a lee shore the want of breaks in its continuity, which denies harbors to the mariner, would be indeed a great and constant calamity.

It may be stated as a general truth that the prevailing winds, and indeed all winds, with the exception to be noted, blow either up or down the coast, and follow the shore more or less closely, which perhaps may be due to the boldness of the coast-line.

The California coast may be distinguished from the north coast by the fact which is very well brought out by the testimony of the most intelligent navigators, given before the Board, that the dangerous storms are less frequent, less violent, and shorter than they are on the Oregon and Washington coast.

The dangerous storms prevail in winter and are southerly. They begin with the wind in the southeast, and they are generally called southeasters. A southeast wind blows off the land, and of itself could not make much sea close to the land. After a few hours the wind works from the southeast to south and then to the southwest, from which direction it blows often with great violence. It is from this latter direction that the heavy sea comes, and then the shore becomes, for a

vessel close in, a lee shore. The storm ends when the wind gets to the northwest.

These storms occur in the latitude of San Francisco generally between the 1st of December and March, during which interval there may be a number, perhaps ten or more, but rarely more than two or three, of any great violence. A day will generally cover the duration of a storm in the latitude of San Francisco.

In the latitude of the Columbia River these storms occur from the early part of November to April. They generally run the same course, but are more violent and succeed each other sometimes in rapid succession for several weeks. Some navigators give Cape Foulweather, which is about 100 miles south of the Columbia River, as the locus of the worst storms. It is at least certain that the coast from Cape Blanco to Cape Flattery is the most subject to these storms.

If we conceive the shore-line from San Francisco northward to be drawn in breadth proportioned to its storm-exposure at different latitudes, the breadth would increase from south to north until we reached some point on the Oregon coast, and from here to the straits the breadth would remain essentially uniform. The center of gravity of this line, which for want of a better term we may call the storm-center of gravity, would be somewhere to the northward of Cape Blanco.

The feature of these storms which perhaps most concerns the matter of this report is the accompanying sea from the southwest, which is generally known to be most formidable. The Board has been assured by some of its most intelligent witnesses, who have visited many of the artificial harbors in different parts of the world, that none of these works are subjected to an exposure that can be compared to that which must be borne by an artificial harbor on this coast.

The following extracts from this evidence are made in illustration. Captain Maury, commander of the City of Tokio, says:

Artificial works on this coast will have to be built to encounter a sea such as no one ever dreamed of trying to resist before. There is no such sea in the world, except south of the two capes, or in the Indian Ocean. I have seen the sea break in 8 or 10 fathoms.

There is no comparison between the heaviness of the southwest sea on this coast and that which has damaged the works at Cherbourg and other places.

Captain Simpson says:

Now, what can you get to stand against the swell in the Pacific Ocean? There may be such swells in other oceans, but I have never seen it.

Captain Debney:

I have seen it myself breaking in 15 fathoms of water in a straight line on the coast. I lost a vessel on the coast, that had decks stove in, moored in 7 fathoms.

At Navarro River, in 1862 or 1863, again, I have known it to break in over 15 fathoms of water right straight along the coast. I have stood on Cape Disappointment and seen it do that. There was no guessing about it.

Capt. J. W. White, of the Revenue Marine, says:

I have seen it break in 15 fathoms off Cape Foulweather.

Capt. Frederick Bolles says:

I have seen it break in 10 fathoms off the Columbia, and in 8, 9, and perhaps 10 fathoms off San Francisco bar.

Captain Connor states that between Trinidad Head and Pilot Rock, in 8 fathoms, three seas boarded his steamer and swept fore and aft. He has known it to break in 7 or 8 fathoms and thinks it breaks in deeper water.

It is also to be remarked that this heavy swell sometimes breaks on the shore in a dead calm. In this case it is probably a distant off-shore wave, the propagation of which towards the coast is favored by the great depth of the sea.

These opinions, if well founded, bear very materially upon the cost of a work intended to resist the action of the waves.

It has been generally assumed that below 15 feet depth at low water the material might be of ordinary sizes of rubble, for the reason that at Cherbourg it was found that below that depth no disturbance of the slopes of the *pierres perdues* took place. It appears, however, that in these waters considerable disturbance must take place at a lower depth than 15 feet, and as a consequence that larger material or flatter slopes will be required, perhaps as low as 20 or 25 feet, than were necessary at Cherbourg at 15 feet depth. Moreover, the superstructure must be composed of stones of unusual size, in order to effectually resist these heavy blows.

Another characteristic of the southerly storms deserves to be mentioned, namely, the accompanying thick weather, which prevents any object, however large, from being seen for any distance more than a few hundred feet. This circumstance has an important bearing upon the accessibility of a harbor of refuge.

The southeasters prevail during the winter and spring, but about this latter season, earlier in the latitude of San Francisco, and later on the Oregon coast, they are replaced by a summer trade wind called the northwester, which blows with great regularity and steadiness for several months.

As a rule, this wind dies away each day with the sun, but every now and then it takes the shape of a moderate gale and blows for three days and nights with considerable force, producing a heavy sea. As a rule, these winds are not disastrous. They sometimes make the shallow bars at the entrance of the small ports quite rough for a time, but they never have the effect to interfere with entrance or exit, either at San Francisco, Straits of Fuca, or Columbia River.

In September and October these winds have much moderated in their force, and the coast is enveloped in fog, often extremely dense. Even during the earlier months there is a good deal of fog along the California coast.

It has already been remarked that there are a number of good shelters along the coast which can be reached during a northwest gale if it is thought desirable. These summer winds tend to increase, if they do not produce, the decided current which is observed to flow down the coast for the greater part of the year, running several miles off shore, with a return eddy current following close inshore. Advantage is taken of this eddy and of the shelter of the coast by small steamers going north during the summer by keeping close inshore. The water close inshore is good, and with the exception of the reefs, which are generally well defined, there is no danger to be apprehended. The southerly gales in the winter are thought by some to produce an off-shore current up the coast, with a corresponding reverse eddy close to the coast.

The soundings close along the coast and in the anchorages and harbors are generally to be found in the published charts. The off-shore hydrography has not been made to any great extent. Off-shore soundings at the Columbia River, Trinidad, and San Francisco are, however, on the charts. These show, particularly for Trinidad, great depths close to shore.

## CHAPTER V.

## MARINE DISASTERS ALONG THE NORTH PACIFIC COAST.

It was supposed that by examining into the circumstances and localities of wrecks along the North Pacific coast some point would be marked prominently as that where vessels would be most in danger of loss from stress of weather.

A wreck report has been kept for some years at the custom house in San Francisco, and for the past five years has been quite full. From this, Table I (Appendix I\*) has been compiled, giving, so far as known, many particulars in regard to vessels lost at sea and on the coast between San Francisco and the Straits of Fuca during the years 1875, 1876, 1877, 1878, and 10½ months of 1879. It also contains a few collisions within the years and limits of coast mentioned, in which one or the other of the colliding vessels were wrecked.

The spring of 1878 having been one of unusual severity, causing much distress to coasters from its violent and almost continuous gales, Table 2 (Appendix I\*) has been made out, giving the miscellaneous damages, exclusive of ships lost at sea and wrecks, reported by various vessels exposed during that year along the coast under consideration.

From an examination of Table 1 it is found the losses for nearly five years were distributed as follows :

	Vessels.	Tonnage.	Estimated loss.	Lives lost.
Lost on shore or in ports:				
Coast of California, north .....	64	9,833.81	\$749,826 00	27
Coast of Oregon .....	15	5,902.04	478,897 50	17
Coast of Washington Territory, south of the Straits of Fuca .....	5	3,442.75	92,500 00	2
Lost at sea, locality unknown .....	10	2,224.23	178,375 00	76
Lost at sea, supposed known .....	16	3,744.36	206,175 00	268
Total .....	110	25,147.19	1,705,773 50	390

The percentage of the total of each item being for—

	Vessels.	Tonnage.	Estimated loss.	Lives lost.
Lost on shore or in ports:				
Coast of California, north .....	0.58	0.39	0.44	0.07
Coast of Oregon .....	0.13½	0.23½	0.28	0.04½
Coast of Washington Territory, south of the Straits of Fuca .....	0.04½	0.13½	0.05½	0.00½
At sea .....	0.23½	0.23½	0.22½	0.88½
	1.00	1.00	1.00	1.00

For the same years the percentage of these losses due to foggy or thick weather, to severe collisions, to carelessness, errors of judgment or in reckoning, and to bad management, as appears from the record were—

	Vessels.	Tonnage.	Estimated loss.	Lives lost.
To foggy or thick weather .....	0.06½	0.16	0.15½	0.00½
To collisions .....	0.04½	0.05	0.06½	0.63
To errors, &c. ....	0.08	0.31	0.35	0.07½
Total .....	0.18½	0.52	0.57½	0.70½

\* Omitted.



Showing that over one-half the tonnage, more than one-half the money loss, and over seven-tenths of the loss of life from these wrecks were due to such causes, and could not have been prevented by any harbor of refuge.

Out of the 110 vessels given in Table 1, 26 were lost in the open sea, 1 was sunk, and 1 damaged by collision in a gale while at anchor in Cuffey's Cove, California, and 82 were stranded in bars and at moorings, or drifted ashore, many of them in moderate weather, at 36 points on the coast of California, 8 in Oregon, and 5 in Washington Territory.

Forty-five of these wrecks were in ports and anchorages in California, besides 6 lost on bars in entering or leaving its rivers and harbors, and 11 at different points, not anchorages, south of Cape Mendocino; 2 were at anchorages on the coast of Oregon, 10 on bars of its rivers and harbors, and 3 at points on its coast during calm or moderate weather; 1 was in Shoalwater Bay, Washington Territory, and 4 at points along that coast south of the Straits of Fuca.

In 11 cases of stranding, 46 lives were lost, 31 of which were in 6 vessels, which were wrecked during fogs, or from errors in management and in reckoning. No one perished in the remaining 71 disasters.

On the coast of California there were 43 vessels wrecked without loss of life, south of Cape Mendocino, at or near some 26 anchorages. That part of the coast is bordered by a belt of fine redwood timber, and there are many small landings for the lumber trade; while at these a vessel is often caught by the heavy swell, which comes in sometimes in calm weather, or, owing to the wind and sea both, cannot get clear of the land; in either case, when both vessel and life are at stake, everything is made as secure as possible, and the crew go ashore, leaving the vessel to her fate. This explains why the loss of life is so small in proportion to the number of wrecks. The same reasons which prevent the vessel from escaping would in general keep her from attempting to double the cape for a harbor of refuge farther to the north.

Of the eighty-two vessels stranded during nearly five seasons, but two were driven from the open sea upon a lee shore by *stress of weather*. This shows plainly the character of the coast is such that vessels passing up and down can have but little difficulty in keeping clear in heavy weather, unless very close in. The coast is almost wholly free from deep and dangerous bights in which they might be caught with a lee shore.

The two vessels referred to as driven ashore by stress of weather are the ship *Commodore*, of 1,129.63 tons, loss \$20,000, which went ashore in dark, squally weather, without loss of life, off Cape Flattery, at the entrance to the Straits of Fuca, at one end of the line of coast, in January, 1877; and the schooner *Fourth of July*, 14.87 tons, loss \$2,000, and three lives, all hands. She sailed out of San Francisco by the North Channel, was caught by a shift of wind in that narrow pass, and was beached just outside the heads of this harbor, in Tennessee Cove, in February, 1877, at the other end of the line of coast under consideration.

The particular locality of the disasters happening to ten of the twenty-six vessels lost at sea is not known; whether any of these could or could not have made a harbor of refuge in time, had there been one, cannot be stated.

Of the other sixteen lost and damaged at sea at known or supposed localities, three were from collisions, namely, the steamer *Pacific*, 850.90 tons, loss \$75,000, with 245 lives, run down not far to the south of Cape Flattery; the schooner *Bill the Butcher*, 87.78 tons, damage \$5,300, towed into port; the schooner *Phil Sheridan*, 158.38 tons, loss \$16,000,



off the Umpqua River; and a fourth, the John Stilson, 36.59 tons, loss \$2,000, struck at night some submerged obstacle between the Farallones and the mainland, and became water-logged. She was abandoned and afterwards towed into port.

Eight more vessels—the bark Clara R. Sutil, the schooner Eden (damaged), the Morning Star, the bark Cambridge, the Eden (lost), the steamer Bouquet, the J. P. Haven, and the Marmion—in all measuring 1,555.63 tons, with loss of \$57,875, and two lives—were wrecked under such circumstances (the first having foundered nearly 120 miles to the westward of Point Arena; five being lost within 100 miles of San Francisco, and two within 50 miles of the Straits of Fuca), they could not have made a harbor of refuge had there been one at any site proposed. The remaining four—the brig Willimantic, the bark Florence, perhaps the brig Perpetua, and the schooner Pacific, measuring together 1,032.88 tons, loss \$50,000, with twenty-one lives—might possibly have been saved by a harbor of refuge to the north of Cape Mendocino.

Table 2 (Appendix I\*), already referred to, shows that during the severe season of 1878 some twenty-eight vessels reported damage of various kinds to the extent of \$35,665, and that at different times nine persons were lost by having fallen, been knocked, or been washed overboard.

From the details it appears that accidents to eleven of these vessels—the bark Whistler, the bark Oregon, the barkentine Constitution, schooners E. W. Prescott, Pauline Collins, Laura Pike, Pauline Collins, L. B. Heywood, bark Oregon, and schooners Barbara and John and Samuel, causing damage to the amount of \$14,410—happened within less than 100 miles of San Francisco, and the most serious of them inside and on its bar. A twelfth vessel, the bark John Jay, sprung a leak off Cape Flattery and put back to Seattle, on Puget Sound, the damage being \$5,000. Eleven more, the Dublin, Atlanta, Flickengen, Annie Gee, J. B. Leeds, Gem of the Ocean, Hidalgo, Hayes, Ancon, Mary Taylor, and the Arcata, were injured to the extent, in all, of \$4,920, most of them but slightly, and three put back to San Francisco and would not probably have gone to any other harbor for refuge.

The remaining five vessels—the Alice, Coursen, B. H. Ramsdell, Townsend, and the Lizzie Madison—were damaged to the extent of \$11,335, and would probably have been spared all or part of this had there been a harbor of refuge to the north of Cape Mendocino.

The result of this investigation into the circumstances of these disasters shows that a great portion of them happened in ports, and does not point to any one place in particular as the most suitable site for a harbor of refuge for the benefit of both local and general commerce.

During the year 1878 there were 4,944 vessels, measuring 1,683,362 tons, passing to and from San Francisco and ports north, including the British possessions, Alaska, and the Arctic Ocean, as shown by records of arrivals and departures kept at the Merchants' Exchange in this city. This total does not include vessels from foreign or Eastern ports bound to the Columbia River and ports north of this city, unless they first touched here. The distribution of these arrivals from and departures for the various ports is given in Table 3 (Appendix I\*).

\* Omitted.

The percentages of these for each State are as follows :

	Per cent. of vessels.	Per cent. of tons.
For ports coast of California, north of San Francisco.....	0.63	0.21 $\frac{1}{2}$
For ports coast of Oregon .....	0.15	0.28 $\frac{1}{2}$
For ports coast of Washington Territory, south of Straits of Fuca.....	0.01	0.00 $\frac{1}{2}$
For ports Straits of Fuca, Puget Sound, and beyond.....	0.21	0.49 $\frac{1}{2}$
	1.00	1.00
For ports south of Humboldt Bay, California .....	0.48 $\frac{3}{4}$	0.12 $\frac{3}{10}$
For Humboldt Bay, California.....	0.11 $\frac{3}{8}$	0.08
For Coos Bay, Oregon.....	0.06 $\frac{6}{10}$	0.05
For Columbia River, Oregon.....	0.05 $\frac{6}{10}$	0.22

From which it is seen that the great bulk of vessels, chiefly small coasters, are engaged in trade along the California coast, and those of heavy tonnage are running to and from the Columbia River and the Straits of Fuca.

## CHAPTER VI.

### INTEREST OF GENERAL COMMERCE IN A HARBOR OF REFUGE.

A study of the evidence given by master mariners before the Board in its public sessions will show an indifference to the subject of a harbor of refuge on the part of all except the masters of small vessels, which, at first must be surprising. The masters of vessels, whose course is laid 100 or more miles off shore, are quite unanimous in saying that they have no interest in the subject. On the other hand, the masters of small vessels, generally schooners, are all anxious to have a harbor. Their unanimity, complete to this point, however, extends no further. When the inquiry is made of them as to the point which will best suit this class of vessels as a whole, the answers are as many in number as the ports with which they trade.

The vessels running to Coos Bay would be best suited at Cape Gregory, which lies at the entrance of Coos Bay. The Crescent City fleet prefers Crescent City. The Trinidad interest prefers Trinidad. The Columbia River trade wants the Columbia River improved. Even the committee of three, appointed by the board of underwriters to present their views, cannot agree. The majority of this committee favors Port Orford; the minority, Trinidad.

Both the transpacific and the distant foreign commerce express no preference for any particular site, nor indeed do they show any interest in the subject. It is, then, not the coast trade as a whole that appears to be interested, but mainly that part of it that never leaves the coast for any great distance—a fraction that may be designated as the inshore coast trade.

Sailing vessels leaving Puget Sound or the Columbia River, bound for San Francisco, first make an offing of 100 or 200 miles before they lay a course for the port of destination. They never, in the course of the voyage, make the coast, except at the beginning and ending. The same is true of vessels going to these ports from San Francisco and from these ports to foreign countries.

The result is that the masters of these vessels are unacquainted with the local and detailed features of this stretch of coast. The schooners, however, bound to ports south of Cape Mendocino keep well inshore and thereby gain a local knowledge of even the most insignificant features. The same is true of coasting steamers, which make from headland to headland. The masters of these vessels have the local acquaintance which is so valuable in fixing the position of the vessel in thick or stormy weather.

Any of the off-shore vessels finding themselves under the necessity of making a harbor in southerly storms would always have the wind fair to the Straits of Fuca. To make a harbor of refuge at any place that has been proposed for artificial improvement, the vessel would have to approach an unknown and inhospitable coast in thick weather, with a heavy sea and all the accompaniments of a southerly gale. There is plainly much less danger in the general case in running for the straits than in approaching the coast. This is the view generally held by masters of deep-water sailing vessels, and it seems to account for the indifference that has been noted.

The inshore coasters and steamers are in quite a different relation to the subject. Their routes habitually lying close to the coast, their familiarity with the shape of the shore in its finest details, the position of kelp, the form of a break, a peculiar outline of a rock or trees, seen in a glimpse, becomes invaluable in determining a position. It is plain that these vessels might with propriety seek for a narrow entrance of a harbor in thick or stormy weather, when it might be foolhardiness for others not so well acquainted with the coast to make the same attempt. This is particularly true of steamers that have their own power of propulsion. The attempt of any sail vessel to reach a harbor of refuge, however well acquainted with the vicinity, must be attended with some uncertainty and danger in thick and stormy weather. Steamers may approach with much more confidence.

These facts, all taken together, the indifference of the off-shore vessels, the entire absence of approach to agreement of the inshore mariners as to the proper location of a harbor, are calculated to show that the general interest of commerce would not, under present circumstances, be greatly benefited by a harbor of refuge established at any particular place. Such a harbor would be a local advantage of the greatest possible kind to the place selected.

If there shall ever be a change in the feeling of those interested in general commerce, such as to make them anxious to have a harbor of refuge, instead of being indifferent, as they now appear to be, it seems to the Board that this conversion must result from a great increase in the coastwise commerce and a change in the manner of carrying on this commerce.

That a great increase in the northern-coast commerce must occur, and indeed is now in the process of developing, cannot be doubted. The great increase of exports from the Columbia River in the past two years; the large immigration into the interior of Oregon, Washington, and Idaho; the construction of the Northern Pacific Railroad, now building, which will help to bring the productions of some millions of acres to the sea-board, either by way of the Columbia or of Puget Sound; the great development of the coal interest of Western Washington, which, with Vancouver Island, promises to furnish the coal of the Pacific, with the kindred interests that will follow; and the general thickening of the population all over this region, must in a few years

multiply the coast trade many times. This seems to be a plain and safe prophecy.

The change in the carrying trade by steam instead of sail appears to be taking place gradually. Omitting reference to other parts of the world where the same phenomenon appears, it will be sufficient to notice the tendencies in the North Pacific, where the circumstances appear to be unfavorable to steam by reason that the winds are regular and that coal is peculiarly expensive. The coast trade from the Columbia River is now done almost altogether by steam. Two large steam colliers are now engaged in the coal trade of the Puget Sound waters. Two steamers are engaged in the coal trade of Coos Bay. The lumber interests of the Northwest support a sail fleet. It is also the lumber interest that maintains the greater part of the coast sailing fleet on the California and Oregon coast. At present nearly everything but lumber is carried mainly by steam. The result of the settlement of the Northwest must then be expected to increase the fleet of coast steamers very much.

If the isthmus canal were to-day a fact, we believe that a large part of the foreign exports of Oregon—wheat and salmon—now taken to European markets by sail, would reach their destinations by steam by way of the canal. The China trade to the port of San Francisco is now largely if not mainly done by steamers, and no reason is seen why the same could not be done with Oregon exports. Sail vessels appear to have reached their maximum. Invention is doing much and may do more to cheapen steam.

It seems, then, to be reasonable to suppose that a few years may see a largely-increased steam fleet on the northern coast engaged both in domestic and in foreign trade. If this shall be the case, this fleet will be a coasting fleet; each vessel will lay its course from headland to headland, passing each as closely as safety or good judgment will permit. It appears to us that when this time comes, and not until then, will general commerce be much interested in this subject.

These views must be admitted to be matters of opinion. They are, however, in the line of development of existing facts and tendencies. They simply suppose present tendencies to continue. They are in accord with the past and the present, so that they can hardly be termed speculative as to the future.

There is room for difference of opinion as to the period of time that will be necessary to bring about this change in its fullness. According to the view that has been advanced, this will come with the completion of the isthmus ship-canal. The growth of the Columbia River commerce in the past few years is illustrated in the following statements:

There are three steamers engaged in the trade from San Francisco to the river. One leaves each end of the line every five days. These steamers are the Oregon, 2,335 tons; State of California, 2,200 tons; Elder, 1,709 tons. A fourth steamer, the Columbia, larger than any of these, has been built for this trade, and will leave the East to come out in the spring of the present year. Taking the average of the tonnage of the three steamers named, 2,081 tons, with seventy-three trips in the year, the yearly tonnage in 1879 becomes 151,913.

For the year ending June 30, 1875, the coastwise steam tonnage was sixty-five steamers, 76,999 tons. This statement shows this tonnage to have been doubled in five years.

The Oregon exports to Europe direct have increased as follows: 1870, six vessels, 4,379 tons; 1874, seventy-five vessels, 70,530 tons; 1878, one hundred and fifty-one vessels, 144,383 tons. This shows the foreign trade as doubled in four years.



The influence of the railroads, the Northern Pacific, and a road from The Dalles to the great wheat-growing country in Eastern Oregon and Washington, remains to be demonstrated. Both roads are under construction. They cannot but add very much to the exports of the north coast.

The exports of cereals from this region by way both of the Columbia River and through Puget Sound, which has within the past four or five years been receiving a very large immigration, will not be far from rivaling those from California in a very few years.

## CHAPTER VII.

### COMPARISON OF SITES.

Our study of the marine disasters that have occurred on the Pacific coast has not indicated any particular point as the one best suited to relieve or prevent these disasters.

The facts heretofore developed have limited the selection of the site for the harbor of refuge to the open roadsteads between Cape Mendocino and the Columbia River. Of these there are six, as follows, beginning in the south: 1st, Trinidad; 2d, Crescent City; 3d, Mack's Arch; 4th, Port Orford; 5th, Cape Gregory; 6th, Cape Foulweather.

The following considerations have further effect in restricting the number open to choice:

1st. *Crescent City*, latitude  $41^{\circ} 44'$ .—Whatever local claims this point may have, we think it cannot be regarded as a competing place for a refuge to commerce in general. The following statement occurs in the report of the Board, dated February 14, 1877. We see no reason to make any change in it:

This harbor is not favorably situated for a breakwater, because—

1st. It is contracted.

2d. On account of the many dangers, sunken and otherwise, both in approaching the coast and inside the anchorage.

3d. Because of the heavy breakers, in southeast and southwest winds, clear across the entrance to the harbor from Steamboat Rock to Round Rock, from Round Rock to Mussel Rock, and from Mussel Rock to the shore.

The entire harbor is feather white with breakers in a gale of wind from the southward.

Crescent City Harbor is usually regarded as the most dangerous roadstead on this coast.

2d. *Cape Gregory, or Arago*, latitude  $43^{\circ} 20' N$ .—This anchorage is remarkable for being the only roadstead on the coast which can be said to afford shelter in a southerly gale. The coast here makes an eastward bend at right angles to its general trend, and the shore from the cape to Coos Head, a distance of 2 miles, runs nearly E.NE. This jut of the coast is bold and gives good cover. From the cape a reef of detached islets, and rocks covered by the sea, makes out in a direction NW., magnetic, for a distance of 3,200 feet, and affords some cover from the westerly sea. If this reef were built upon for a distance of 3,200 feet from the light-house, and a second breakwater of equal length, having a direction N.NE., magnetic, were constructed to cover the anchorage from the northerly sea, a very good shelter would be made for all circumstances of weather. The area thus covered would be about 300 acres, outside of the 4-fathom curve, with an average depth of about 8 fathoms, sandy bottom. This arrangement of lines would make

the entrance opening to the north  $1\frac{1}{2}$  miles wide from the end of the breakwater to the 4-fathom curve along the beach, with a depth over this width running from 10 fathoms at the west to the beach in gradually lessening soundings.

The entrance to Coos Bay is close under the cape. Coos Bay has a considerable trade, which is much embarrassed by the character of the entrance. Its bar is shifted in alignment and often shoaled in depth by a single storm. A harbor under Cape Gregory would, then, be a great convenience to a large local interest, which might possibly be much increased by rail communication with the interior of Oregon, a part of the country without a good, convenient, natural outlet. The cape cannot be far from what we have called the storm center of gravity of the coast. The cape stands well out as a salient, and has no reefs to make the approaches difficult or dangerous. These are strong points. They induced the Board to direct a special examination of this point to be made, including in this the hydrography of the anchorage, a search for stone suitable for construction, which is not found close to the cape, and a study of the currents and sand movements, which in this part of the coast are on a grand scale.

The report of First Lieutenant Payson shows it to be probable that any construction such as we have indicated for the reef off the cape would be likely to arrest the great sand flow that comes from the north, doubles the cape, and reappears on a large scale several miles to the southward of the cape. Such a result would soon impair the usefulness of the harbor.

It is also an objection that, by reason of the harbor opening to the north in order to make an entrance in southerly weather, a vessel must come into the wind. With the heavy sea that prevails in such storms, and under short canvas, we are informed, and believe it to be true, that to attempt this maneuver in the limited space between the end of the breakwater and the breakers on the beach would be a hazardous step. This objection would not apply to steamers.

It may also be remarked that no stone suitable for construction is to be found at the cape or in its vicinity, and that the soft sandstone that now forms the north spur of the cape, which would be a part of the breakwater, is under a process of rapid degradation, which must ultimately carry it away. The stone used for construction would be found on Coos River, 20 to 25 miles distant. The arrangements for placing the stone would be to load it at the quarries on scows, carry it to Coos Head, or some convenient point adjacent, then transfer it by a railroad about 3 miles long, depositing it from a staging built out on the reef. Without a railroad the scows would have to cross the bar in order to reach the line of the work. This route we regard as impracticable.

3d. *Mack's Arch*, latitude  $42^{\circ} 11'$ .—This anchorage is moderately well protected from the force of northwesterly winds. The shelter, however, is not nearly so good as that of Port Orford. A chain of high detached rocks makes it nearly a straight line from Crook's Point in a southerly direction for  $1\frac{1}{2}$  miles. The main shore, going south from the point, trends to the eastward, and its general line makes an angle of  $40^{\circ}$  with the line of the reef. Between the two lines is included a triangular-shaped area, widest at the entrance and narrowing to the head, which could be tolerably well protected from the westerly sea by a construction connecting the detached islets. To be at all adequate, the construction ought to be 6,100 feet long, 2,400 feet of which would be in water ranging from  $8\frac{1}{2}$  to  $17\frac{1}{2}$  fathoms. The entrance would open to the south and have a width of  $\frac{7}{8}$  mile or  $\frac{3}{4}$  mile to the 3-fathom curve. The

area covered, outside the 3-fathom curve, would be about 370 acres. The area having over 4 fathoms is 260 acres.

The wide entrance and the triangular shape of the area directly covered would be likely to act against a reduction of the waves entering around the end of the breakwater, and it is doubtful whether the requisite smoothness would be secured. Stone is not convenient in sufficient quantity.

4th. *Yaquina Point, latitude 44° 40'.*—This point is sometimes called Cape Foulweather. It is called Yaquina Point on the Coast Survey chart. It is a bold headland, making out a half mile from the shore. It affords a limited shelter on the southerly side from northwest winds. A reef makes from the point in a northerly direction, nearly parallel to the shore, and leaves a narrow area between the reef and the shore which would be protected from the westerly sea if the reef were occupied by an adequate construction. The entrance to this protected area would be from the north by a narrow channel close to the beach, which, in the opinion of the Board, would hardly be practicable.

5th. *Port Orford, latitude 42° 44'.*

6th. *Trinidad, latitude 41° 03'.*

It remains to compare the claims of these two points, between which a choice must be made.

The Board, in its report of February 14, 1877, preferred Trinidad to Port Orford. It used the following language in regard to the latter point:

This place is the best summer roadstead on the entire coast between Point Reyes and the Straits of Fuca. When vessels anchor close in to the northern shore, they are protected by a high point of land and some outlying islets to the south of it from the summer waves coming from the west or northwest. The harbor, however, is entirely exposed to the southerly gales of winter, when the great rollers approach the shore from a southwest direction. This port is well located for a harbor of refuge. Stone for the foundation of a breakwater is abundant in the immediate vicinity. The holding ground is good, and, doubtless, it would be possible to make a good harbor of refuge here by the construction of a breakwater about 1 mile long on the line we have indicated.

Our only objection to it is the great depth of water on the proper line of breakwater, and consequent enormous cost.

There is the further objection to making a breakwater here, that about half way between Point Orford and Cape Orford, and some 3 miles off the coast, there is to be found a great group of rocky islets and sunken rocks, called Orford Reef, which render the approach to Port Orford from the north somewhat dangerous.

The following language of the same report applies to Trinidad:

This harbor is in latitude 41° 03', about 240 nautical miles north-northwest of San Francisco. It is about 20 miles south of the middle point of the coast between the entrance into San Francisco Harbor and the mouth of the Columbia River. Geographically it is therefore well situated for a harbor of refuge between these two places.

Trinidad Head, a bold, picturesque headland, protects a limited anchorage from northwest winds, but the harbor is entirely exposed to southerly storms. This headland rises to the height of 380 feet above low water. It is of metamorphic sandstone, covered above the height of 80 to 100 feet above the water with a few feet of earth, which supports a thick growth of scrub bushes.

The rock here appears to be of better quality than is generally found along the coast. The fact that it is such a bold, projecting headland, with deep water around its southern face, shows that it has been able to resist the denudation of the sea, and would seem to bear out this conclusion.

There are no sunken dangers in approaching Trinidad, for the only rocks to be found lie close inshore, just off the high headland, and their position is well marked by two high rocks, one of which rises to the height of 80 feet, the other to the height of 100 feet above the water.

The Board was favorably impressed with the advantages of Trinidad for a harbor of refuge, and as it is called upon to designate the point which should, in its judgment, be selected for such harbor between San Francisco and Puget Sound, the Board, with the information now before it, gives the preference to Trinidad Harbor.

Both of these ports are accessible in southerly weather, and they can be departed from when the weather changes to northerly.

The consideration of this subject a second time by the Board leads the majority to prefer Port Orford. A minority prefers Trinidad.

The following points in favor of Trinidad are admitted :

1. That there are no reefs, either in its approaches or to the leeward, and that the port has no hidden dangers.

2. That Trinidad Head is the property of the Government, and that, so far as can be judged without excavation sufficient to expose the limits of the rock, there appears to be enough material conveniently at hand to build the breakwater.

3. That a given area of protected anchorage ground can be covered here at a considerably less expense than the same can be done at Port Orford.

Other arguments have been advanced in favor of Trinidad as follows :

1. That the greater part of the marine disasters that have involved loss of life and property have occurred to the south of Trinidad.

2. That the number of vessels arriving and departing from Trinidad and ports south of it is much greater than from ports to the north, including the Columbia River.

In regard to these arguments, it may be said that the study of the marine disasters, elsewhere noted in this report, does not indicate that Trinidad would have been more effectual as a harbor of refuge in preventing these disasters than Port Orford would have been.

While it is true that the number of vessels trading south of Trinidad is greater than the number trading to the north, it is also true that these vessels are, as a rule, of very small tonnage.

It is also believed to be true that the trade of the narrow belt of country which finds its outlet by this numerous fleet has nearly if not entirely reached its maximum. Its principal cargo is redwood timber, and the next generation will probably witness a decline in this business. It will probably be a continually lessening fraction of Pacific commerce.

In regard to Port Orford, it is admitted that there is a serious objection in the reef to the leeward, and that there is some objection, although minor, in the Rogue River Reef, which lies 14 miles to the southward. It has already been admitted that, by reason of its deeper water, the construction will be more expensive than at Trinidad. This objection is not without compensation. If the sea breaks in 10 fathoms of water, it is certainly desirable to place the construction in about this depth.

The relative advantages and disadvantages of Trinidad and Port Orford are well worthy of consideration. There is certainly room for a difference of opinion, but above all local considerations, so long as these latter are not vital, there appears to be a controlling circumstance which directs our opinions in favor of Port Orford. This circumstance is geographical position. Port Orford is near the middle part of the great storm belt. Trinidad is near its southern extremity. Port Orford divides the unharbored stretch of coast lying between San Francisco and the straits into two nearly equal parts of 350 miles each. Trinidad divides the coast into two unequal fractions of 250 miles and 450 miles, and makes the leeward fraction both much the longer and much the more stormy. Port Orford will by its position be accessible to all vessels that can make Trinidad, and, in addition, will be a refuge to all sail vessels between Trinidad and Port Orford.

According to the view held by the Board, a harbor of refuge at Trinidad can never have the importance or produce the benefits to general commerce that are necessary to justify the expenditure of money re-



quired to build it. If there is any place on the North Pacific coast where a large expenditure is justifiable it is Port Orford. The geographical position of Port Orford, regarded as an asylum for general commerce, is then, for the reasons given, much to be preferred to that of Trinidad. It is locally well situated in that it is farther west and is on a salient part of the coast. It is close to the route of the steam commerce of the northwest coast. It is well marked by prominent and easily recognized landmarks. The approach from the windward direction is free and open. The Port Orford reef is a danger to vessels coming from the windward in thick weather. Missing the entrance of the harbor a vessel might be in great danger from the reef. There is, however, an inside passage between the reef and the shore of  $1\frac{1}{2}$  miles in width with full 10 fathoms of water. The reef itself consists mainly of large rocky islets standing out boldly with deep water between, although not without hidden dangers. The southern rock (Fox Rock) is a wash, and is therefore the most dangerous point. We must suppose that the conditions that justify the harbor of refuge will cause the dangerous points in the reef to be marked by signals, which will lessen the dangers for sail vessels and make the approaches quite secure for steamers.

The isolated condition of the middle interior valleys, lying in the northern part of California and in the middle and southern part of Oregon, has been mentioned. At present the trade of this country reaches the sea either to the south by way of San Francisco or to the north through the Columbia River. There is no good port on the coast for an outlet, and there is as yet no communication across the mountainous country from the coast to the interior. In Appendix D,\* relating to Coos Bay, there will be found a description of a railway route by way of the Coquille River to connect the Umpqua Valley with the coast. If this route over the mountains is practicable to Coos Bay, it seems probable from our knowledge of the country that there would be no insurmountable obstacle in carrying it to Port Orford. It is possible that in this way a harbor at Port Orford would incidentally tend to favor the interests of a considerable interior country.

## CHAPTER VIII.

### DESCRIPTION OF PORT ORFORD.—PLAN AND PROFILE.

Port Orford is the best shelter from the northwest winds that is found on the northern coast. Cover from these winds is given by a jut of the coast to the westward 1 mile in length. The land is high, being as much as 350 feet in the western end, falling to 50 or 60 feet at the junction with the main line of coast. The western part rises nearly vertical from the sea to the height of 80 or 100 feet, making an inaccessible cliff. The rock thus exposed to the action of the waves indicates by its form and appearance great power of resistance to denudation. The cliff, overlaid by soil, upon which is a growth of trees and other vegetation, is composed mainly of rock, a metamorphic sandstone similar to that found at other points on the coast. Its geological age is Tertiary or, later, Secondary. Similar stone in California is classed as Cretaceous. Mineralogically it is a calcareous sandstone. It does not, at least elsewhere, as a rule, quarry in large pieces. The weight of similar stone in

\* Omitted.

California varies from 160 to 170 pounds per cubic foot. It occurs very conveniently to the work in a way to permit the mound to be formed in the most economical way, namely, by deposit from cars running on a track supported by a scaffold on piles. Fine timber suitable for the scaffolding is found conveniently in great abundance.

Beginning at the root of the promontory which now forms the roadstead a narrow sand-beach skirts the coast to the south, backed by a bluff which comes down to about high-water mark. This want of room on the beach is unfavorable for the manufacture of large artificial stones. There is, however, just north of the point, a wide sand-beach and ridge separating a lagoon from the sea.

The bay inside of the breakwater runs in depth from 10 to 3 fathoms quite close inshore. The holding ground is about the same as is found in the other roadsteads. It is sand, but not so hard as to refuse the grip of an anchor.

The resources of the adjacent country have never been developed to any extent worth noting, and are probably in great part unknown.

The village of Port Orford stands on the bluff where it is lowest, and may possibly have twenty houses. There are a few small farms in the neighborhood.

Coal is said to exist in considerable quantities a few miles from the coast.

The point is well marked by conspicuous hills. Humbug Mountain is a notable feature.

The rise of tide in extreme spring is 11 feet. The ordinary spring tide is 7 feet, and neap tide 4 feet.

Port Orford is 6 or 7 miles south of Cape Blanco. Between the two points, about 2 miles off shore, lies the Port Orford Reef, which has been described elsewhere. Fourteen or 15 miles to the southward lies the Rogue River Reef, which has been elsewhere noted. There are no hidden dangers in the harbor. Ingress and egress are convenient and favorable. A sail vessel can enter with southerly winds, which prevail during the period she will need shelter, and she can leave with ease when the wind becomes northerly.

The Board is not aware that a topographical survey of the Port Orford Head has ever been made. This ought to be one of the first steps taken in this improvement. At present we only allude to the fact that it will be necessary to project sea-coast defenses here, and remark that the excavation for the breakwater ought to be made in reference to these defenses.

#### PLAN.

It is in evidence before the Board that waves break into combers in depths of 8 and even 10 fathoms of water. In consideration of this fact, the Board is of the opinion that the breakwater ought not to be placed in much less than 10 fathoms. An alignment of the breakwater parallel to the crests of the waves, which it is planned to resist, gives two important advantages, namely, a given length covers the maximum area, and, secondly, the structure, if of *pierres perdues*, will have a minimum exposure to injury.

Observations of the direction of the great waves can be made only in the winter, and the Board has not had the opportunity to make them. Inquiry of those best informed develops some difference of opinion as to the direction of the crests of the waves. This point seems to be of great importance, and without a clear knowledge of the facts it is impossible to definitely fix the true alignment. The location which is

shown upon the accompanying map must therefore be understood as subject to a revision under a further acquaintance with the facts.

As projected, this line of the breakwater is not connected with the shore. An interval of 180 yards is left between the western end and the shore, so as not to interfere with the littoral current. It is possible that this width ought to be reduced, perhaps one-half.

The length of the breakwater proposed and estimated upon is 1,320 yards. If it shall prove to be the case here, as in some other places, that the increase of commerce requires more room, it will be possible by extending the breakwater to increase the area.

As now projected, the width of the entrance is 950 yards to the 3-fathom curve on the beach. The maximum depth at the entrance is  $9\frac{1}{2}$  fathoms. The depths of anchorage run from 10 fathoms to 3 fathoms. The area covered is 260 acres, outside of the 3-fathom curve. The breakwater at the end nearest shore is in  $8\frac{3}{4}$  fathoms. At the outer end the depth is  $11\frac{1}{4}$  fathoms, and between these points the depths vary from  $10\frac{1}{4}$  to  $11\frac{3}{4}$  fathoms.

#### SECTION OF BREAKWATER.

The section of the breakwater has been the subject of much study, which has embraced—

1st. A vertical wall founded on a mass of rubble at a depth below the supposed limit of disturbance by the waves.

2d. A vertical wall founded at low water.

3d. A long foreshore of a slope of one-twelfth, between high and low water, the mass being supposed to be composed of natural stones; and

4th. A foreslope composed of artificial stones of such weight as not to be disturbed by the waves.

A vertical wall, founded on the bottom like the Dover wall, we regard as impracticable on account of expense, if for no other reasons. We do not see the way clear to making a firm foundation for a masonry wall built on a mass of rubble, particularly if the upper surface of the rubble is placed 25 or 30 feet below low water. A mass of rubble built to high water or above, would doubtless in time be so consolidated by the force of the sea as to permit a masonry wall to be founded upon it at low water; but as we understand the experience elsewhere, this kind of construction is of doubtful propriety. We are therefore reduced to a choice between a long flat foreshore, formed of stone in natural sizes, or a steeper slope made of artificial stones of a size much greater than can be expected from a quarry.

The profile as adopted by the Board consists of a mound of rubble with natural slopes until it reaches a point 25 feet below low water. The material in this mound is placed so that the larger pieces shall be on the seaward side.

Beginning at a point 25 feet below low water, a constant slope of  $\frac{1}{3}$  is carried to a point 10 feet above high water. This slope, as far as low water, is composed of the largest sizes of natural stones, supplemented, if necessary, by 10-ton artificial stones. Above low water the breakwater is to be made of stones of 25 or more tons weight, sufficient to hold their places under any action of the sea. The width on top, 10 feet above high water, is 40 feet, and the interior slope is 1 on 1.

If we confine ourselves to natural stones, we are confronted at the outset by the inquiry whether natural stones of sufficient size can be obtained from the quarry in sufficient numbers. Admitting this to be the case, and taking the slope between high water and a point 2 feet below low water at  $\frac{1}{12}$ , which is that at Holyhead, we have calculated

the cost of this section. We find it to be about the same as the section of artificial stones of large size.

The placing of these large stones above low-water line promises to be a work of difficulty. In some cases abroad the stones above low water have been made in place. It occurs to the Board that this may prove to be the best construction. It has the advantage that the stones may be made of any desired size, and may be arranged in something like a wall, but with this difference, that the integrity of the work will not be greatly affected by settlement, as has been the case with a-coursed masonry wall at several places, notably at Alderney. With this kind of construction the weight of these blocks may be 60 or even 100 tons, and the stones may be placed in the best positions to resist the waves.

In explanation of whatever incompleteness there may appear to be in this part of the report, it is fair to note the difference in the circumstances of this case and those in European waters.

Port Orford is an outpost, without commerce or population. The resources of the country are unknown. There are no constructions in the way of buildings or roads to uncover the rocks or make known the resources in material. It is virgin ground.

European ports provided with breakwaters are at commercial points in the midst of a numerous and intelligent population, easily accessible, with prices well established, and all physical circumstances a matter of common knowledge for generations. The resources of art are at hand in abundance. At Port Orford there is nothing that is not natural; everything else must be created. It will then, we believe, be admitted that at present every point of the harbor construction cannot be laid down with the precision that it is reasonable to expect under usual circumstances.

The following estimate is submitted. In this no allowance for voids is made. The breakwater is calculated as solid.

We add an item of \$250,000 for preliminary expenses in purchase of land, construction of buildings, and equipment of the work.

If it shall be the judgment of Congress that this work be constructed, it will be economy to make appropriations of about \$1,000,000 a year until about half the work is completed. The area then covered would probably be sufficient for the requirements of commerce for some years. The work could then be suspended until further growth made the necessity for enlargement apparent.

#### ESTIMATE.

	Cubic yards.	Cost per cubic yard.	Total cost.
Concrete blocks weighing 25 tons and over.....	252,570	\$12 00	\$3,030,840 00
Concrete blocks weighing 10 tons.....	132,000	10 00	1,320,000 00
Large rubble averaging 4 tons.....	294,800	5 00	1,474,000 00
Small rubble.....	1,670,350	1 25	2,087,937 50
			7,912,777 50
Contingencies, 10 per cent.....			791,277 75
Purchase of land, construction of buildings, &c.....			250,000 00
			8,954,055 25

Very respectfully submitted.

C. SEAFORTH STEWART,  
*Lieut. Col. of Engineers.*  
 G. H. MENDELL,  
*Lieut. Col., Corps of Engineers.*  
 G. L. GILLESPIE,  
*Major of Engineers.*



STATEMENT MADE BY LIEUTENANT-COLONEL R. S. WILLIAMSON, CORPS  
OF ENGINEERS.SAN FRANCISCO, CAL., *March 24, 1880.*

I do not agree with the majority in some of the statements in chapters 5, 6, 7, and 8, nor do I agree with them as to the point they have selected for a harbor of refuge, for reasons which will be fully set forth in a minority report.

R. S. WILLIAMSON,  
*Lieut. Col., United States Engineers.*

The CHIEF OF ENGINEERS, U. S. A.

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LETTER FROM THE SENIOR MEMBER OF THE BOARD OF ENGINEERS  
FOR THE PACIFIC COAST.

OFFICE BOARD OF ENGINEERS FOR PACIFIC COAST,  
*San Francisco, Cal., April 21, 1880.*

SIR: I have the honor to state that a copy of the report by a minority of the Board, dated April 17th instant, in relation to the selection of a site for a harbor of refuge between San Francisco and the Straits of Fuca, with its appendixes, has this day been received.

The original, it seems, has been already forwarded to your address.

The Board notices that this report, dated some six weeks later than the majority report, is largely devoted to a review of the opinions of the majority.

The Board has fulfilled the duty required of it by the law. It sees no reason to change the views it has expressed. It has not, however, any desire to enter into controversy, and therefore thinks it best to make no reply, and will make none unless it is informed a reply is necessary or desirable.

Very respectfully, your obedient servant,

C. SEAFORTH STEWART,  
*Lieut. Col. of Engineers,*  
*Senior Member of the Board.*

The CHIEF OF ENGINEERS, U. S. A.

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## MINORITY REPORT.

SAN FRANCISCO, CAL., *April 17, 1880.*

GENERAL: The Board of Engineers for the Pacific Coast have made a thorough examination of the localities that might be considered available for a harbor of refuge between San Francisco and the mouth of the Columbia River, and have come to the unanimous conclusion that Trinidad and Port Orford are the two points which present advantages greater than any other points within that limit. When the question had to be decided which of the two points in question presents superior advantages over the other, the opinion of the Board was not unanimous; three members of the Board decided upon Port Orford, the other one, myself, consider that Trinidad presents the greater advantages. In consequence of this difference of opinion on this radical point of the loca-

tion of the proposed harbor of refuge and on some minor points, I have declined to sign the report prepared by the majority, and I respectfully request to present my reasons somewhat in detail why I differ from them.

It may be remembered by those conversant with the history of this subject of a harbor of refuge that the House of Representatives, in 1876, passed a resolution asking for an examination of certain harbors on the Pacific coast, north of San Francisco, "with a view of establishing a breakwater and harbor of refuge, with estimate of probable cost." The matter was referred to the Board of Engineers for the Pacific Coast, and they made a report dated February 14, 1877. That Board was presided over by General B. S. Alexander, since deceased, and associated with him were Colonel Stewart, Colonel Mendell, and myself. That Board unanimously agreed upon Trinidad, in the following language:

The Board was favorably impressed with the advantages of Trinidad for a harbor of refuge, and as it is called upon to designate the point which should, in its judgment, be selected for such a harbor between San Francisco and Puget Sound, the Board, with the information now before it, gives the preference to Trinidad Harbor.

Nothing resulted from that examination and report, but last year Congress called for another examination of this subject, and the matter was again referred to the Board of Engineers for the Pacific Coast. The death of General Alexander and the addition to the Board of Colonel Gillespie make the number of the members of the Board the same as before. Two of the members who then voted for Trinidad have changed their views and now advocate Port Orford, and as Colonel Gillespie also prefers Port Orford there is a majority in favor of that place. The above is a concise history of the operations of the Board with regard to this subject during the last four years. It seems to show that the two points, Trinidad and Port Orford, are considered as presenting decided advantages over any others, and the vacillating action of two of the Board tends to show that the claims in favor of each of these two points are nearly equally balanced. For this reason it would seem the more necessary that a close and searching examination of the advantages and disadvantages of the two points in question should be made.

In the majority report there are certain arguments admitted in favor of Trinidad, as follows:

That there are no reefs either in its approach or to the leeward, and that the port has no hidden dangers.

That Trinidad Head is the property of the Government, and, so far as can be judged without excavation sufficient to expose the limits of the rock, there appears to be enough material conveniently at hand to build the breakwater.

That a given area of protected anchorage ground can be covered here at a considerably less expense than the same can be done at Port Orford.

That the greater part of the marine disasters that have involved loss of life and property have occurred to the south of Trinidad.

That the number of vessels arriving and departing from Trinidad and ports south of it is much greater than from ports to the north, including the Columbia River.

They also admit, as unfavorable to Port Orford, the existence of a reef to leeward, and its deeper water, which would cause more expense in a construction at that place than at Trinidad.

These admissions, made in a general way, without an examination of the consequences which must follow from them, are considered by the majority as nothing compared to "a controlling circumstance which directs our opinions in favor of Port Orford. This circumstance is geographical position."

It appears to me that this subject deserves and requires a much more searching examination than was given by the members of the majority in their report. For example, when that report admits that "a given

area of protected anchorage ground can be covered here" (Trinidad) "at a considerably less expense than the same can be done at Port Orford," it does not indicate in any way whatever what was the consequence of such an admission, and the natural inference drawn by a casual reader would be that the fact admitted was of trifling importance. I propose to go into an examination of the facts here involved, and to show what would be the comparative cost of a harbor of refuge at Trinidad and one at Port Orford, so that a fair comparison of the two estimates can be made.

In the same way I shall examine some other portions of the report, where, in my judgment, the statements have been of too general a character or they have been made without sufficient support to sustain them, and I propose to present a mass of strong evidence to show why I have considered Trinidad superior to Port Orford as the locality of the proposed harbor of refuge.

No description of Trinidad is given in the majority report, and nothing was said about it other than the admissions above quoted. The Coast Survey chart of the harbor, which is accessible to all, tells in the most concise way its peculiarities. By a study of this chart any one must be convinced that there is a small area, in from 3 to 6 fathoms of water, which is perfectly protected from westerly, northerly, and easterly winds, but that it is entirely open to southerly winds. There is one peculiarity of this harbor, however, which has not been represented on the chart. It has been stated in evidence before the Board that at Trinidad the heavy swell, which is so disastrous to vessels at anchor when subjected to it, comes from a direction magnetic west. The letters of S. Bainfield and F. P. and J. A. Hooper, herewith inclosed\* and marked A and B, are two, in connection with many others sent on with the majority report, to confirm this fact. This is important, for it shows that if a breakwater were built from Trinidad Head to Pilot Rock and a line were drawn magnetic west from the southern extremity of the Rock, the area included by this line, the line of the breakwater and the 3-fathom curve, will be  $1\frac{1}{2}$  square miles.

The total distance from Trinidad Head to Pilot Rock, by an accurate measurement on the Coast Survey chart, is 2,680 feet, or 40 feet more than a half mile. Of this distance 100 feet are in 6 fathoms, 600 feet in  $7\frac{1}{2}$  fathoms, 1,760 feet in  $8\frac{1}{2}$  fathoms, and 220 feet in  $8\frac{3}{4}$  fathoms. Adopting the same estimates of cost as those adopted by the Board of 1877, I find that the cost of a breakwater between these two points is \$3,797,000, or a little less than \$3,800,000, as is shown in the following table:

Depth of water.	Number of feet.	Price per foot.	Total cost.
6 fathoms .....	100	\$1, 201	\$120, 100
$7\frac{1}{2}$ fathoms .....	600	1, 356	813, 600
$8\frac{1}{2}$ fathoms .....	1, 760	1, 440	2, 554, 400
$8\frac{3}{4}$ fathoms .....	220	1, 495	328, 900
	2, 680	.....	3, 797, 000

The Board of 1877 made an estimate for a breakwater at Port Orford 1 mile long at \$10,507,343, or nearly 2.8 greater than the one at Trinidad.

No matter what may be said with regard to the accuracy of these two

\* Omitted.

estimates, as they were calculated in the same manner, the same values being used in both cases, their *relative* values must be considered worthy of confidence.

The majority report contains an estimate of a breakwater at Port Orford three-fourths of a mile long, at \$8,954,055. If the cost of extending this breakwater another quarter of a mile were in the same proportion, the cost of one a mile long would be \$11,938,740, or about \$1,500,000 more than the estimate made by the first Board for a breakwater at that place.

But by examining the Coast Survey chart of Port Orford it will be readily seen that the distance between the proposed breakwater and the 3-fathom curve is in no case but very little over a half mile, and that the area protected by a breakwater even 1 mile long is less than half a square mile. Of course if the breakwater is made shorter than 1 mile the area to be protected will be proportionally less. In the majority report it is estimated that the area protected by the work they propose will be 260 acres, or a little over four-tenths of a square mile.

If a breakwater at Port Orford 1 mile long and protecting an area of less than the half of a square mile is considered sufficient for that place, the same area may possibly be considered sufficient at Trinidad. To secure such area there it will be only necessary to build a breakwater from Trinidad Head to a middle point between it and Pilot Rock. As the estimate for a breakwater for the whole distance between those two points was a little less than \$3,800,000, the estimate for one of half that length would be less than \$1,900,000, or about one-sixth of the sum estimated to protect a similar area at Port Orford. But a breakwater at Trinidad protecting an area of  $1\frac{1}{2}$  square miles can easily be built to Pilot Rock without finding over  $8\frac{3}{4}$  fathoms of water, and if necessary it could be extended to the south a half a mile farther without reaching 10 fathoms. If such a line of breakwater were built the area protected would be 2 square miles. Such a work at Port Orford could not be built on a line located more to the south than on the projected line without enormous cost, for the water deepens very rapidly in that direction.

I believe I have given a fair estimate of the cost of a breakwater at each of those two places, under the supposition that the same cross-section would answer for both. But this is far from being the case. It has been brought forward in evidence that Port Orford is one of the most exposed points on the coast of Oregon. In fact, in the majority report, a strong argument in favor of Port Orford was that it is about the middle of the storm belt, and because it is on a salient point of the coast. These facts are undoubtedly true, but do they not make it exceedingly improbable that any work of the kind we are considering at Port Orford would stand a winter's storm? It has been stated that none of those great works on the English coast are subject to an exposure that can be compared to that which must be born by an artificial harbor on the coast of Oregon. If that be the case, of which there is very little doubt, it would be advisable to locate the harbor at a point as little exposed as possible. The evidence has shown that Trinidad fulfills that condition better than any other point on the coast.

But even if a breakwater can be made at Port Orford that will not be destroyed by winter gales, it is evident that larger blocks of stone and wider cross-section must be used than at Trinidad, and hence the comparative cost must be much greater at the former place than at the latter.

I have so far considered the subject of the comparative cost of making a harbor of refuge at the two places, and I consider that the enormous expense of the one as compared with the other should be a sufficient



reason for deciding upon Trinidad, if no other reasons were advanced in favor of that place and against the other. But other reasons do exist which I consider of importance.

The majority report states as follows :

In regard to Port Orford it is admitted that there is a serious objection in the reef to the leeward and that there is some objection, though minor, to the Rogue River Reef, which is 15 miles to the southward.

In their report it is not stated what consequences are to follow because of these reefs, and whether their existence is a matter of slight importance or of serious import. I therefore beg leave to examine the subject more in detail.

By examining the Coast Survey chart of the coast between Port Orford and Cape Orford, a distance of about 7 miles, I find that a vessel in leaving Port Orford and bound up the coast would have to steer magnetic west for 5 or 6 miles, and then she could change her course to the northward. By these means she would go to the westward of and around the reef. If she could not do this she would have to go between the reef and the shore. At the lower end of the reef the distance between it and the shore is about 2 miles, but at the upper end, between it and the lower part of Blanco Reef, the width is scarcely more than 1 mile. The direction a vessel must steer to use the "steamer channel" (it is so marked on the Coast Survey chart) in order to pass to the eastward of the reef is about north-west. This is a very convenient passage for a steamer in fine weather, but suppose that a sailing vessel in thick weather and in a heavy southwest gale were desirous of making for Port Orford, where we will suppose a harbor of refuge exists, and suppose that she happens to get a little too much to leeward, she could not wear around and go to sea again, and the gale causing her to drift rapidly to the northward, she must as a last resort try to make the passage through the channel between the reef and the shore, which channel is not free from sunken dangers. As above stated, this passage is practicable for steamers in fine weather, but in this case it would be perfectly impracticable, because a vessel under short sail and hauled up close to the wind, as she would have to be, would make almost as much leeway as headway, and the consequence would be she would soon be driven ashore. It must be remembered that it is against the southerly gales, and especially against the southwest gales, which are always the most severe and continue the longest, that the protection afforded by a harbor of refuge is mostly required, and the more I study the matter the more serious it seems to me is the obstacle presented by this reef.

The majority are of the opinion that geographical position is of primary importance in the selection of a site for a harbor of refuge, and they argue that a point midway between San Francisco and the entrance of the Straits of Fuca should be selected. I am not prepared to give to geographical positions the importance they have given to it. A great deal has been said and used as an argument in favor of Port Orford; that it divides the unharbored stretch of coast lying between San Francisco and the Straits of Fuca into two nearly equal parts. Trinidad divides the coast between San Francisco and the *mouth of the Columbia* into two nearly equal parts. As no one has supposed that the harbor of refuge would be located north of the mouth of the Columbia, and as that fact was so apparent to the Board that they stopped the examination of the coast at Astoria, I consider that a point nearly midway between San Francisco and the mouth of Columbia River is a more

desirable locality than one midway between San Francisco and the Straits of Fuca.

The majority also argue that as the commerce of the great Northwest, of the Columbia River and Puget Sound ports is large now and is increasing yearly, the place to be selected should be at some point which would afford shelter to that increasing commerce, and they state that Port Orford fulfills that requirement, and they give that as a reason why they have decided in favor of that place. The evidence before the Board, and particularly that presented in this minority report, proves conclusively that a harbor of refuge at Port Orford would *not* be of any benefit to or be used by the large and substantially equipped steamers and sailing vessels that are engaged in that northern trade.

By examining the evidence of mariners and others given before the Board, and by the appendixes\* to this report, it is shown that any harbor of refuge on this coast ought to have its entrance opening to the southward, so that vessels seeking its shelter in a disabled condition or under shortened sail could approach it with a free wind. The entrance to the harbor, as projected at Port Orford by the majority, is from nearly due east, and it would be impossible for a vessel, even in good condition, to get into such a harbor in a southwest gale and with the heavy sea that rolls in from the westward at such times, for in approaching the harbor she would have a fair wind and sea, but would be sailing directly upon a lee shore, and to make the entrance to the harbor she would be compelled to come up sharply to the wind, and be in the trough of the sea—an evolution which mariners state would be dangerous for any vessel to attempt, even if in good condition and with plenty of sea-room. But in this situation she would have her decks swept, and would run the risks of having her masts or rudder carried away, and thus crippled would soon drift into the breakers to the leeward. From the foregoing it is seen that should any vessel in a disabled condition attempt to make into the harbor she would certainly be lost.

The breakwater, as located by the majority, terminates in  $11\frac{1}{4}$  fathoms of water. In their report they state :

It is in evidence before the Board that waves break into combers in depths of 8 and even 10 fathoms of water.

They also state that:

In consequence of this fact, the Board is of the opinion that the breakwater ought not to be placed in much less than 10 fathoms.

A glance at the Coast Survey chart on which the line adopted by them is plotted will show that the water shoals up to  $9\frac{1}{2}$  fathoms in a distance of less than 300 yards from the end of the breakwater and in a direct line with it. In view of the above facts, it is plainly evident that during a heavy southwest gale, and with the sea breaking into combers in 10 fathoms of water, no steamer or sailing vessel could haul sharply to and get into the harbor, for the entrance to it at such times would be a seething mass of breakers, and the steamer or vessel in attempting to get in would have to pass through the trough of them.

In view of the fact that at Port Orford Harbor the sea frequently breaks in 10 fathoms, and often in 14 fathoms (see testimony of H. B. Tichenor, an old resident of Port Orford, in Appendix G\* to this report), and also of the fact that a southern entrance to a harbor of refuge on this coast is an absolute requirement to it, the necessity of changing the direction of the line of breakwater from that adopted by the majority is

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\* Omitted.

apparent. A careful study of the chart of the harbor shows that this change can best be made by commencing at the initial point of the line adopted by the majority and extending it for a distance of three-fourths of a mile in a *southeast* direction. A breakwater of that length and located on such a line would terminate in about 20 fathoms of water. If Port Orford is finally decided upon as the site for the harbor of refuge, this change must be made. The majority in discussing this subject make use of the following language:

The location which is shown on the accompanying map must therefore be understood as subject to revision under a further acquaintance with the facts.

I have given the subject of a breakwater at Port Orford much thought and study, and I am of the opinion that the line of location as indicated by me is the only practicable one that can be adopted for this exposed place. With a breakwater built on this line its entrance would be free from breakers, and a vessel could approach it in heavy southwest weather with a fair wind, and would not have to haul up to the windward for anchorage until after passing into smooth water beyond its terminus.

The plan for a breakwater three-fourths of a mile long on the line indicated by me, and in such deep water, must be very different from the plan adopted by the majority. The same slopes might be used, but, owing to the force of the immense seas that would be thrown against it, it would have to be of much greater width of base and its slopes would have to be built of much heavier blocks of stone. Without making a detailed estimate of its cost it is apparent that the amount required for its construction would be enormous, at least three times as much as the amount stated by the majority in their report as the estimated cost of the work proposed by them. This amount is a little less than \$9,000,000.

From the evidence given before the Board, and from the statements made by the majority in their report, it is plainly to be seen that no system of piling, in even 10 fathoms of water, can be made to withstand the force of the waves that would be thrown against them in Port Orford Harbor, even in summer. Hence the comparatively cheap and expeditious method of building the breakwater, by transporting the materials on railroads supported by piles, could not be carried out, and the much slower and more expensive method of transportation by large scows towed into position by steam-tugs would have to be adopted. The working season at Port Oxford could not begin before May 1, or continue later than November 1. On account of this short working season the date of the completion of the breakwater must be far in the future.

A careful investigation and consideration of the foregoing pages proves conclusively:

- (1) That an enormously increased expenditure of money over the amount estimated by the majority would be necessary to build an available harbor of refuge at Port Orford.

- (2) That the dangerous reefs, violent gales, heavy seas, and thick weather in its vicinity would deter mariners from seeking its shelter even if it were possible to build it.

- (3) That even if built it "can never have the importance or produce the benefits to general commerce that are necessary to justify the expenditure of the money required to build it."

The fact that the coast commerce between San Francisco and all intermediate ports as far north as the Columbia River is increasing each year is admitted by every one who has given this subject any study or attention.

The valuable paper on the resources of the redwood timber belt between San Francisco and Big Lagoon, 4 miles north of Trinidad, compiled by John Dolbeer, esq., of this city, and corroborated by the testimony of many of the prominent persons engaged in the redwood lumber trade of this coast, proves conclusively that this belt of timber is far from being exhausted. The demand for it is increasing yearly, and with double the present rate of annual consumption, which is now 171,000,000 feet, it will take sixty-nine years to exhaust the present supply, without taking into consideration the growing timber.

Besides this lumber interest the large number of shipping points, or outside ports, between San Francisco and Trinidad, are the only outlets of an extensive agricultural and grazing country, the products of which can only find a market by way of the ocean. All through this large section of California the population is increasing from year to year; new farms are cleared up and the exports of wool, dairy, and agricultural products are increasing.

The port of Eureka, on Humboldt Bay, 20 miles south of Trinidad, is the most important port between San Francisco and the mouth of the Columbia River. It is the commercial port and outlet of a large timber, agricultural, mining, and grazing section of country. An illustration of the growth of the coast commerce between San Francisco and Trinidad is shown by the fact that five years ago the exports of wool from Eureka were nominal, while in 1879 the amount exported exceeded in money valuation its lumber exports during the same period, which amounted to nearly 50,000,000 feet; besides its exports of lumber and wool, large quantities of agricultural and dairy products are annually exported.

The number of steamers and sailing vessels arriving at and departing from the port of Eureka during 1879 was almost double the similar arrivals and departures from the Columbia River, and was also more than two-thirds as many as those which went to the Straits of Fuca. These steamers and sailing vessels ranged from 100 to 500 tons' capacity each. This port also supports a large ship-building interest; seventy vessels, ranging from 100 tons to 500 tons each, have been built here during the past fifteen years.

The foregoing facts disprove the assertion made in the majority report that this portion of the coast commerce "will probably be a constantly lessening fraction of Pacific commerce."

The redwood timber belt continues from Trinidad as far north as the boundary-line between this State and Oregon, where it ceases. The amount of it available for export between Big Lagoon and the northern boundary of this State is much greater than the amount stated by Mr. Dolbeer to exist south of that place.

Immediately north of Trinidad is the port of Crescent City, which is also the outlet of an extensive lumber, mineral, agricultural, and grazing country, which is fast filling up with a thrifty population. Crescent City is also the natural outlet for the products of the counties of Curry, Josephine, Jackson, Lake, Grant, and Baker in Oregon, and of Del Norte, Modoc, and Siskiyou in California. A railroad is already projected from this place to tap the fertile counties of Oregon above mentioned. When this railroad is built, the commerce of this port, which is now quite large, will be greatly increased.

Between Crescent City, Cal., and Coos Bay, Oregon, are several small shipping ports, to which small steamers and schooners trade. The next place of importance, however, north of Crescent City, is Coos Bay. This bay has a large commerce, which must increase rapidly in the future,



especially when the railroad now projected from it to the interior of Western Oregon is built.

A short distance north of Coos Bay is the Umpqua River, which has considerable commerce, and which is the outlet of the large and fertile Umpqua Valley.

North of the Umpqua River and distant from it 60 miles is Yaquina Bay, from which a railroad is also projected to tap the grain-growing counties of Western Oregon, the products of which now find their way to the sea by the long and circuitous route of the Willamette and Columbia rivers.

Besides the commerce before mentioned, it must be remembered that there is a large and growing commerce between the ports on the southern coast of California and the ports of Northern California and Oregon.

In addition to the foregoing facts many pages might be filled with statistics to prove that the commerce of the coast between San Francisco and the Columbia River, not including the commerce of the latter, instead of having reached the maximum, has hardly yet begun to be developed.

A harbor of refuge at Trinidad would be of great benefit to the vast commerce I have been considering and describing, the largest portion of which is in its vicinity or to the south of it.

There is another advantage in favor of Trinidad which may be considered of even greater importance than any previously considered. I refer to the comparative ease with which it can be fortified, and the capacity of the harbor, with the line of breakwater I have suggested, to form a roadstead for a fleet of forty first-class ships of war, assuming that each ship requires a circle to swing in of 800 feet in diameter. Strong defensive works can be easily built at Port Orford, but in my opinion Trinidad can be more easily and strongly fortified at less cost. A study of the chart of the coast shows that Trinidad possesses natural advantages in this respect which are not possessed by Port Orford. The peculiar formation of Trinidad Head at once impresses even a casual observer that it is admirably adapted as a site for defensive works. It is nearly circular in shape, and rises from the ocean in an unbroken and almost vertical wall of rock to a height of about 80 feet, and then assumes a mound-like shape to its summit, which is 380 feet above mean low tide. Batteries could be erected upon it which would command its approaches from every direction. It is connected with the mainland by a low, narrow neck of sand.

Pilot Rock is of great importance in this connection. It is distant from the head 2,680 feet; it is about 100 feet in height, nearly circular, and about 300 feet in diameter. It is admirably located as the site for a first order light-house and steam fog-signal and for a small battery of heavy guns. This rock also forms a fine natural abutment for the breakwater.

In considering the location of a harbor of refuge in connection with its availability as a rendezvous for naval vessels, there are several points worthy of attention, as the area of the harbor, its freedom from sunken rocks or other dangers in its approaches, its sheltered position, and its proximity to the great commercial center of the coast. The valuable papers on this subject prepared for me by Admiral D. McDougal, U. S. N., Capt. P. C. Johnson, U. S. N., and Commander C. J. McDougal, U. S. N., show the importance of the foregoing requirements. A harbor of refuge at Port Orford would not fulfill any one of these essential requirements. The small area of its harbor, the dangerous reefs in

its vicinity, its exposed position, and lastly, and most important of all, its great distance from the commercial center of this coast, are fatal objections to it, even if a harbor could be made there with any reasonable expense.

A harbor of refuge at Trinidad would fulfill each and every one of these requirements; it would be large enough to accommodate a large fleet of war vessels, its approaches are free from dangers of every kind, it has a sheltered position, and is within easy distance of the great commercial center of the Pacific coast of the United States.

I fully agree with the majority in saying that the evidence before the Board has shown that it is not the coast trade as a whole which is interested in the establishment of a harbor of refuge, but only that portion of it which is engaged in the commerce of the small harbors or inlets, most of which are on the coast of California. This subject was fully discussed by the majority in the early part of chapter vi of their report. The latter part of that chapter, however, is purely speculative, and while it is possible, and even probable, that some of these prophecies may be fulfilled, there are others which I consider very improbable, such as the statement that "sail-vessels appear to have reached their maximum"; and while great stress is laid upon the fact that the northwest trade is evidently increasing rapidly, not a word is said about the corresponding increase in the coast trade between San Francisco and all ports between it and the mouth of the Columbia River. Assistant George Davidson, of the United States Coast Survey, has furnished me, at my request, with a "wreck chart," which I have the honor to forward to you with this report. A study of this chart seems to lead to important conclusions. It shows that the great majority of the wrecks that have occurred between San Francisco and the entrance to the Straits of Fuca have been south of Trinidad. In fact, the vast majority of these wrecks have occurred in the vicinity of Mendocino City, and between there and San Francisco. Mendocino City is about midway between San Francisco and Trinidad. From Mendocino City the number of wrecks has gradually diminished with the increase of latitude. This being the case, it appears to me that it affords a strong argument against selecting a point for the harbor of refuge north of Trinidad.

Professor Davidson has also sent me answers to several questions I propounded to him on the subject of an artificial harbor for this coast, but as he has informed me that he is about to send to the Board of Engineers for the Pacific Coast, at their request, a much more elaborate paper on the subject, and as the senior member of that Board has informed me that he will, upon its receipt, forward it to you for your information, I have not included his paper among those which will form the appendixes to this report. Hence I respectfully refer you to that paper for a full discussion of his wreck chart. The following quotations, however, are from the papers sent to me by Professor Davidson:

The conditions of a long season of northwesterly winds on this coast are remarkably favorable for sailing-vessels bringing their full cargoes of lumber, produce, grain, &c., from Oregon and Washington Territory. The passenger traffic mostly supports the steamer trade; but this must eventually be turned landwards when the railroad is built from Redding to Roseburgh, and much of the higher classes of freight will move in that channel. Even in winter sailing-vessels, have, after nearly every southeaster, favorable northwest winds for making a passage to the southward.

I cannot see what articles of production, whether timber, coal, wheat, or other agricultural products, can profitably support steamers, even if fuel were cheaper than it is to-day, because the steamers bound to the Columbia River and the Straits of Fuca must be of considerable size, and that involves heavy running expenses with only a moderate gain in time with freights that are not perishable.

The coastwise trade between San Francisco and the Columbia River cannot be said to have reached its maximum, although the character of the traffic and of the vessels

has changed. The statistics of 1878 indicate that only  $4\frac{1}{2}$  per cent. of the traffic northward of San Francisco goes to the Columbia River in sailing-vessels and 50 per cent. in steamers. The development of the country bordering the Columbia River is steadily increasing, and the Northern Pacific Railroad must to some reasonable extent increase the traffic; whilst, on the other hand, the future building of the railroad from Redding to Roseburgh must largely decrease the steamer traffic.

I am of the opinion that either Port Orford or Trinidad would be of little benefit to the commerce of Puget Sound or Columbia River, mainly because the traffic to those places is in large vessels or in steamers that are better found and manned than smaller vessels. They keep a good offing or can control their courses, and would prefer keeping at sea in a southeaster rather than hazard the seeking for a harbor of refuge in unfavorable weather. I can hardly imagine a capable captain with a well-found vessel running her away for a port of refuge which might happen to be to leeward of him. If he could run for a port of refuge, he could run for his port of destination and lay off it until the weather abated.

You have essentially limited your questions mainly to the relative merits of Trinidad Bay and Port Orford, and thereto I answer that in view of the foregoing conditions, and of others which I shall elaborate in my answer to the commission of which you are a member, I should give my judgment in favor of Trinidad Bay.

In further explanation I refer you to the letter above mentioned, and to aid you in forming your judgment I sent you a copy of the statistics of the commerce of 1878, and also a copy of the wreck chart for eighteen years, before referred to.

In my letter to the commission I discuss the claims of other points on the coast, the character of the commerce, the seasons, the teachings of the wreck chart, statistics, &c.

Many sailing-vessels have been lost during the heavy storms of winter while "hanging on" near their port of destination. These vessels are generally of that class engaged in the coastwise commerce between this port and the ports of California and Oregon as far north as Yaquina Bay, and after having nearly completed their voyages, rather than run before a heavy southwest gale which in two days might take them as far as the Columbia River, they strive to hold their own. If a harbor of refuge were located in a favorable position, say 250 miles from their port of destination, which usually is San Francisco, such vessels would doubtless run for it to avoid the wear, tear, and danger in striving against the storm. If such a harbor were located at Trinidad it could be easily reached by any sailing-vessel during a heavy southwest storm, even if the vessel was as far south as Point Reyes at its commencement.

Again, many vessels are lost while holding on to their moorings and anchors at the many outside ports between San Francisco and Trinidad. These vessels, when once fast to their moorings, which are exceptionally strong in these outside ports, would rather trust to them than put to sea at the commencement of a southwest storm, with an uncertainty as to how far north they would be driven. For this class of vessels, which are never provided with the extra sails and provisions necessary to weather out a gale at sea, a harbor of refuge at Trinidad would be of great benefit, for they could run for it with confidence, and within a short time after the commencement of the gale would be safely at anchor behind the breakwater.

The majority, in their last chapter, describe Port Orford and point out its advantages. One would naturally be led to suppose that the advantages there described are peculiar to that place, but that is not the case. They say:

Port Orford is the best sheltered roadstead from the northwest wind that is found on the northern coast.

Trinidad is as well sheltered from the same wind, though the area protected is not so great.

The land is high. \* \* \* The rock exposed to the action of the waves indicates by its form and appearance great power of resistance to denudation.

Trinidad Head shows the same.

The cliff \* \* \* is a metamorphic sandstone.

So it is at Trinidad.

The rock—

Occurs very conveniently to the work in a way to permit the mound to be formed in the most economical manner by deposition from cars running on a track supported by a scaffolding on piles.

The rock at Trinidad is even more convenient, but I believe that a track supported by a scaffolding on piles at Port Orford would be destroyed by the first winter's storm.

Fine timber, suitable for scaffolding, is found conveniently in great abundance.

So it is at Trinidad.

This want of room on the beach is unfortunate.

There is plenty of excellent beach at Trinidad.

I might go on in the same way, but this is enough. Almost all the advantages pointed out in favor of Port Orford occur at Trinidad, and there are some in favor of Trinidad which are not found at Port Orford.

The position for a breakwater at Trinidad Harbor, as recommended by me, was fully described in the early part of this report. It is on a direct line between Trinidad Head and Pilot Rock, and is shown on the chart which accompanies this report. The length of this breakwater is 2,680 feet, and it will give a protected anchorage area of nearly  $1\frac{1}{4}$  square miles. The section of the breakwater I propose for this place is shown on the sketch accompanying this report. In building it, I propose to use natural rock as it comes from the quarry, the small stones and rubbish being used in the hearting, reserving the larger pieces for the outer slopes. There is little doubt that a sufficient quantity of large pieces of rock, ranging from  $\frac{1}{2}$  to  $7\frac{1}{2}$  cubic yards, can be found for this purpose, while quarrying out the large quantity of stone required to build the breakwater.

I am inclined to think that a railroad supported on piles would stand against the average swell that comes into Trinidad Harbor. Quarries on the Head could be opened in several different places at the same time, and thus afford great facilities for the rapid construction of the work. I am inclined to believe that after these quarries are once opened, and with the modern appliances for quarrying and handling large masses of rock at hand, such as steam-drills, steam-derricks, &c., at least 1,500 cubic yards of rock could be daily taken from the quarries and placed in position in the breakwater.

The cubical contents of the breakwater, calculated as a solid structure, is 1,311,826 yards. It is very probable that work at Trinidad could be carried on for 250 days in the year, because of its sheltered position. If I can place in position 1,500 cubic yards per day during 250 days in the year, the entire structure can be completed in  $3\frac{1}{2}$  years from the date of its commencement, provided the necessary amounts required for it are yearly appropriated by Congress.

It will be observed that I have provided for this structure being built in a similar manner to the Portland breakwater, which is described as a "great dike of *pierre perdue* dumped upon a given line until raised above the level of the sea." In the drawing of a cross-section of a breakwater, which is forwarded with this report, there is shown no wall of masonry on the top, as is the case with many of the English breakwaters. This mass of masonry is, in my opinion, of doubtful utility, and adds very



materially to the cost of the structure. I submit this drawing merely to show a cross-section of a breakwater without this mass of masonry, and not to critically compare the slopes with others suggested in the majority report; though, in my opinion, they will compare favorably with any of them. It is probable that they will be changed from the original as shown in the sketch, and be modified by the action of the waves, as has been the case at Portland and Holyhead.

The following estimate for the cost of the suggested breakwater at Trinidad is respectfully submitted:

For piling and trestle-work for four lines of railroad track from the Head to Pilot Rock, 2,144 piles, with stringers put on and ready for putting down the rails, at \$20 .....	\$42, 880
2 miles of steel rails ready for use, at \$8,000 .....	16, 000
1 mile of steel rails complete for side tracks to quarries .....	10, 000
2 locomotives and tenders, at \$8,000 .....	16, 000
60 dump cars (30 for spare cars) at \$600 .....	36, 000
4 steam derricks (portable), at \$3,000 .....	12, 000
Tools and miscellaneous equipments .....	20, 000
295,895 cubic yards large rubble, from 2 to 10 tons, at \$4 .....	1, 183, 580
1,015,931 cubic yards small rubble up to 500 pounds weight, at \$1 .....	1, 015, 931
	<hr/>
	2, 352, 391
Contingencies, 10 per cent .....	235, 239
	<hr/>
Total .....	2, 587, 630

The foregoing estimate, though liberal, is, of course, only an approximate one, as there are many contingencies which may arise to modify it.

In the early part of this report a comparative estimate of the cost of a breakwater at Trinidad and Port Orford was considered, and the estimate there made for Trinidad was a little less than \$3,800,000. The estimate here presented is made in a different manner, but the main cause of difference between the two is on account of the fact that the former estimate included in it an item for the construction of an expensive and massive wall of cut-stone masonry.

If Congress should decide to build a breakwater at Trinidad on the line I have suggested, the work should begin at Trinidad Head and be gradually extended in the direction of Pilot Rock. If it were built one-quarter of a mile in length, it would afford a protected area of one-half of a square mile. This can be built for less than one-half of the above estimate, as the depth of water in the first quarter of a mile is less than in the remaining distance. When so far completed, the work can be stopped until such a time in the future as the increase of commerce may necessitate its extension. The cost of such portion of the breakwater would be little over \$1,000,000.

The following is a description of the papers\* forming the appendixes which accompany this report:

Appendix A is a letter from Capt. S. Bonnifield relative to the direction of the swell entering Trinidad Harbor and of the sheltered position of that place.

Appendix B is a letter from F. P. and J. A. Hooper, ship and mill owners, relative to matter in Appendix A.

Appendix C is a letter from Judge J. E. Wyman, of Eureka, Humboldt County, California, giving commercial statistics of the port of Eureka, 20 miles south of Trinidad.

Appendix D is a copy of a letter sent by me to John Dolbeer, esq., mill and ship owner, and a copy of his reply thereto, relative to the available supply of redwood timber between San Francisco and Big Lagoon, 4 miles north of Trinidad, which is corroborated by the representative men in the redwood lumber and shipping interest of the section of the country above specified, whose signatures are appended to Mr. Dolbeer's paper.

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\* Omitted.

Appendix E is a copy of a letter sent to the most prominent corporations, firms, and individuals interested in the commerce of the Columbia River and Puget Sound ports, and their answers thereto, relative to the best location for a harbor of refuge to benefit their trade.

Appendix F is a letter from Capt. E. Alexander, of the Pacific Coast Steamship Company, giving his views on the location of a harbor of refuge.

Appendix G is a letter to H. B. Tichenor, esq., ship and mill owner, and formerly a resident of Port Orford, and his answer thereto, relative to the direction of the waves there in winter storms, depth in which water breaks, &c.

Appendix H is a copy of a letter to C. T. Hopkins, esq., president of the California Insurance Company of this city, and his answer thereto, relative to the location of a harbor of refuge; the object of my letter having been to obtain an expression of opinion from the board of marine underwriters on the subject, as their committee disagreed in their evidence given before the Board last July. Mr. Hopkins's letter states several interesting facts in connection with this subject.

Appendix I is a copy of a letter from Capt. J. N. Bruce, relative to the practicability of vessels putting to sea from the outside ports at the commencement of a storm, and gives reasons why so many vessels and lives are lost at these places.

Appendix J is a copy of a letter sent by me to Rear-Admiral D. McDougal, Capt. P. C. Johnson, and Commander C. J. McDougal, all of the United States Navy, and their replies thereto. It contains valuable information as to the requisites for a harbor of refuge, from which direction its entrance should open, and its requirements as a rendezvous for a fleet of war ships.

Besides these appendixes, I forward with this report the following charts:\*

(1) A Coast Survey chart of Port Orford and the reef. On this chart are shown the lines for a breakwater recommended by the majority and by myself.

(2) A Coast Survey chart of Trinidad, showing the line of breakwater as recommended by me.

(3) A wreck chart, furnished me by the senior officer of the Coast Survey on this coast, showing the number of vessels and lives lost, and the location of the places where lost, during the last eighteen years. It also shows the number and tonnage of vessels engaged in the commerce of this coast for the year ending August 31, 1878. This chart tells a graphic story, which would require many volumes to express in writing.

(4) A sketch of a cross-section for a breakwater, as recommended by me for Trinidad Harbor.

The construction of the proposed harbor of refuge for this coast is a matter of national interest and importance, and I therefore respectfully ask a careful consideration and investigation of the facts set forth in this report and its appendixes; the gravity of the subject suggests it, and political economy demands that it should be made before its location is finally decided upon.

Very respectfully, your obedient servant,

R. S. WILLIAMSON,  
*Lieut. Col., United States Engineers.*

To the CHIEF OF ENGINEERS, U. S. A.

LETTER FROM THE SENIOR MEMBER OF THE BOARD OF ENGINEERS  
FOR THE PACIFIC COAST.

OFFICE BOARD OF ENGINEERS FOR THE PACIFIC COAST,  
*San Francisco, Cal., May 1, 1880.*

SIR: On the 1st of December, 1879, a letter was written Assistant George Davidson, United States Coast and Geodetic Survey, under the direction of the Board, by its recorder, asking the results of his observations and experience on this coast, that the Board might avail itself of these in the matter of the selection of the site for a harbor of refuge on the North Pacific coast.

\* Not printed.

The reply to this request under date of April 20, 1880, has been received.

The selection of a site and the report of the Board on the subject having been made some weeks ago, the interesting communication of Assistant Davidson formed no part of the proceedings had before the Board in that matter.

At the request of the Board this paper and a copy of the letter to Assistant Davidson are forwarded for the information of the Chief of Engineers.

Very respectfully, your obedient servant,

C. SEAFORTH STEWART,  
*Lieut. Col. of Engineers,  
Senior Member of the Board.*

To the CHIEF OF ENGINEERS, U. S. A.

LETTER OF THE BOARD TO ASSISTANT GEORGE DAVIDSON, UNITED STATES COAST AND GEODETIC SURVEY.

OFFICE BOARD OF ENGINEERS FOR THE PACIFIC COAST,  
*San Francisco, Cal., December 1, 1879.*

DEAR SIR: The Board of Engineers for the Pacific Coast is charged by Congress with the duty of selecting a point on the northern coast, south of the Straits of Fuca, for the location and construction of a harbor of refuge.

The Board seeks authentic information in regard to all points which bear upon the proper location of this harbor, from all persons who are acquainted with the coast, its topography, the currents adjacent to it, or its meteorology.

The duties of the officers of the Coast Survey necessarily make them observers of physical circumstances which have important bearings on a question of this kind, and the Board expresses the hope that you will aid its judgment with the result of your observation, expressed either orally before the Board or in writing, as may be more agreeable to you.

Very respectfully, your obedient servant,

A. H. PAYSON,  
*First Lieut. of Engineers, Recorder of Board.*

Prof. GEORGE DAVIDSON,  
*United States Coast and Geodetic Survey.*

LETTER OF ASSISTANT GEORGE DAVIDSON, UNITED STATES COAST AND GEODETIC SURVEY.

UNITED STATES COAST AND GEODETIC SURVEY,  
*Δ Martinez East, Cal., April 30, 1880.*

DEAR SIR: I received in December a letter from Lieutenant Payson, secretary of the Board of Engineers, asking me on behalf of the Board to give them what information, &c., I possessed upon the subject of a harbor of refuge upon the coast north of San Francisco.

Captain Patterson, Superintendent United States Coast and Geodetic Survey, authorized me to answer your inquiries.

Regular and special duties have in part delayed my answer to this late date, but I was anxious to collect statistics of traffic and disasters upon this coast, by which my judgment might be corrected. For this purpose Assistant Gershom Bradford, of the Survey, has tabulated the statistics of traffic with every port north of San Francisco for one year ending August, 1878, and has compiled a wreck chart which exhibits the total and partial losses by shipwreck for the eighteen years ending 1878.

The question of a harbor of refuge has been present to my mind during my work upon this coast since 1850, and was more particularly suggested when making the voyages to and from the north. In later years it has had increased interest from the growth of our commerce, and the personal examinations which I have made of foreign breakwaters. Many years since a hydrographic survey was made, upon my recom-

mentation, of the vicinity of Destruction Island, for the especial purpose of learning whether it would afford protection under its lee to vessels seeking shelter in heavy winter storms. And I had early sought information from the Hudson Bay and Russian navigators, whether they had in their experience found any point where their vessels could lie in safety during southeast storms. The subject was always kept in view when writing the different editions of the Coast Pilot, and when visiting certain localities to gather useful information therefor.

Although familiar with the general character and increase of commerce on the coast, and with the disasters and losses upon our seaboard, I had not gathered the statistics which are now embraced upon a chart of the coast north of San Francisco, and which are very forcible and suggestive.

The character of the weather upon this coast is too well known to be described in detail; and the remarkably bold frontage of the coast line, nearly free from outlying dangers, is so marked that navigation may be said to possess a wholly different phase to what it has on the eastern seaboard, or what it would have on the western coast of Europe.

In its longer features, the high bold coast line has a northwest trend for 213 statute miles from San Francisco, in latitude  $37^{\circ} 48'$ , to Cape Mendocino, in latitude  $40^{\circ} 27'$ , thence it runs nearly north for 545 statute miles to Cape Flattery, at the entrance to the Strait of Fuca, in latitude  $48^{\circ} 24'$ . This last long stretch is marked by a slight receding of 20 miles in 160 miles in the coast line between Cape Mendocino and Cape Orford, which lies in  $42^{\circ} 50'$ , and is a few miles west of Cape Mendocino. Thence to Cape Flattery there is a regular curve to the eastward which reaches a depth of 33 miles.

The whole coast is bold and high, reaching elevations of about 3,000 feet, and has deep water close inshore; the 1,500-fathom curve lies within 25 to 75 miles of the coast. There are reefs of limited area lying off Cape Mendocino, Point Saint George (Crescent City), Rogue River and Cape Orford, and the Flattery Rocks; otherwise it is singularly free of dangers.

For one-half the year the prevailing winds and swell are from the northwest; from November to March the prevailing winds are from the southward, with a heavy, ugly swell from the south and southwestward, accompanied by rainy and thick weather. The "southeasters" generally work round to the southwest, and upon the breaking up of the storm the wind veers rapidly to the northwest, with clear weather and a more regular sea.

Under nearly all circumstances of weather this coast *never forms a dead lee shore*, and I cannot recall a single instance where a vessel with an offing of a few miles has been driven ashore by stress of weather. In the southeast gales of winter there is occasionally some severe weather off the coast south of Cape Mendocino, but the heaviest storms may be said to stretch northward of that cape and to increase in severity as we proceed northward to Alaska. And yet, in the heaviest winter storms, a vessel with a fair offing runs no risk of being driven ashore from stress of weather alone.

From my experience, and from what I have gathered from navigators, there is much less danger in heavy winter weather to a well-found and properly managed vessel, heading off shore, than for even the same vessel endeavoring to make any given point on the coast, supposing a harbor of refuge to exist within reasonable distance. This is eminently true of all deep-water or sea-going vessels, and may be also said of steamers which can control their courses. The larger sailing-vessels make their voyages at a reasonably safe distance from the coast; the steamers keep closer inshore, but as a rule at a safe distance.

It may be a safe assertion to make that, as a matter of commercial competition, all vessels go to sea with the least possible number of men and the least practical expense of outfit; but the shorthandedness of a small craft is a much more serious factor in her safety in emergency than that of a larger vessel, and, therefore, the smaller vessel is on that account at a greater disadvantage; but the smaller vessel cannot naturally contend against heavy storms as can the larger ship, besides which the smaller vessel takes greater risks in following her business close along-shore in a hundred different exposed anchorages, whilst the larger deep-sea vessel may see the land only when she is leaving or making her port.

If we look at the actual size, outfit, and manning of the larger vessels making the longer voyages upon the northern coast to the Columbia River and the Strait of Fuca, and to the steamers which are in that trade, and to their experience in the navigation of winter and of summer, we shall find that they have, on these grounds alone, comparatively small need for any harbor of refuge on this coast. Even considering all the wrecks that have occurred in the last thirty years, it is highly probable that very few vessels would have been saved by the existence of a harbor of refuge.

And even with a reasonable increase of the commerce of the coast we may suppose an equal increase in the efficiency of the vessels. The size and character of the vessels employed in the northern trade has improved every year; in the early days we had "old tubs" sent out from the East that were made to do sea service long after



they should have been broken up; this class of vessels has given place to vessels built upon the coast for their special object of traffic.

The question naturally arises, whether the increase of steamers will be proportionally greater, or as great hereafter as it has been. I think the main bulk of the traffic will be done by sailing-vessels, because of the favorable character of the summer winds and the prospective building of a railroad from Redding to Roseburg, which will then control most of the passenger movement; that is now probably the largest item in the receipts of the steamships; we may admit that coal may become a cheap fuel for the steamers, and yet not cheap enough to compete with sails in carrying the great bulk of the trade.

Even in winter it is well known that the northwest wind succeeds the southeaster, and is thus a favorable wind for lumber and produce laden vessels bound southward.

I am convinced that the risks of this better class of vessels would be greatly increased if they were to keep their courses in winter close along the coast, in order to take advantage of a port of refuge; and it is a reasonable supposition to make, that any captain who should exhibit a tendency to run for such a port upon the approach of every southeaster would soon lose his command.

In all these considerations I think we are justified in leaving out of view any supposed claims of foreign commerce. I cannot see how it should influence the decision; certainly it would have less claim than the commerce from the Atlantic or Gulf seaboard. This is not an international question. Even if foreign commerce had a sentimental claim on the score of humanity, it must be borne in mind that the vessels engaged in that commerce are necessarily large, well found, and adequately manned; and in coming upon either of the three principal ports on the coast in heavy weather can more safely keep at sea until the weather moderates and improves. It would, in fact, be extra hazardous for a foreign vessel coming upon the coast at such a season, from a long voyage, to seek for a harbor of refuge far out of her course.

It may be safely asserted that every foreign vessel, as well as every eastern vessel, coming upon this coast in winter weather, and fearing to approach the bar of the Columbia, would prefer to lay off her port until the bar was passable.

The wants of the smaller class of vessels are always forcibly presented to us, because their fitness for sea duty is so disproportionately small compared with the dangers which they necessarily incur. In fact, for several months in the winter season the smallest craft do not venture to their usual summer anchorages, and it is very doubtful if they could command any insurance. If a harbor of refuge existed within reasonable distance of their ports, it is quite likely that their trade would be carried on, in part, during the winter.

Whilst the main part of the trade to the higher northern ports is principally carried on by the larger class of vessels, there are, nevertheless, many smaller ones which go far north, but the bulk of the trade by the smaller vessels will be found southward of Port Orford or Crescent City, and to which large vessels rarely go. In fact, we can deduce from the statistics what size of vessel can profitably be employed to a given latitude.

#### STATISTICS OF TRAFFIC AND WRECKS.

The extended table of statistics of the traffic for 1878 and the wreck chart embracing the casualties for eighteen years may be condensed into the following table for the sake of generalizations:

*Tabular exhibit of the tonnage between San Francisco and northern domestic ports for the year ending August, 1878; also, tabular statement of the losses by wreck on the same coast for eighteen years, 1861-1878.*

[Compiled from the wreck chart of the United States Coast Survey.]

	Vessels and tonnage, one year.			
	Sailing-vessels.		Steamships.	
	Number.	Tonnage.	Number.	Tonnage.
All ports from San Francisco to the Strait of Fuca ..	1,904	439,151	349	288,695
Percentage of the above.				
From San Francisco to ports between—				
Point Reyes and Shelter Cove .....	53	17	14	
Shelter Cove to Crescent City (Crescent City not included) .....	12	8	27	
Crescent City to Columbia River (Columbia River not included) .....	9	7½	16	
Columbia River to Shoalwater Bay .....	3	4	30	
Shoalwater Bay (not included) to Strait of Fuca ..	22	64	12	

*Exhibit of tonnage between San Francisco and northern domestic ports, &c.—Continued.*

	Losses for eighteen years.			
	Total.		Partial.	
	Vessels.	Loss.	Vessels.	Loss.
	Number.	Dollars.	Number.	Dollars.
All ports from San Francisco to the Strait of Fuca ..	266	6,489,020	522	1,835,020
From San Francisco to ports between—	Percentage of loss.	Amount of loss.	Percentage of loss.	Amount of loss.
Point Reyes and Shelter Cove .....	37	1,545,150	30	280,495
Shelter Cove to Crescent City (Crescent City not included) .....	10	415,000	8	70,034
Crescent City to Columbia River (Columbia River not included) .....	22	895,450	39	353,782
Columbia River to Shoalwater Bay .....	14	567,998	11	102,859
Shoalwater Bay (not included) to Strait of Fuca.	17	688,300	12	108,703
Total of vessels and amounts .....	206	4,111,898	319	915,873

NOTE.—The total loss of life north of Point Reyes is 657; north of San Francisco, 711.

This table and the wreck chart tell a very strong story in a very few words and in a very unique form. Placed upon the chart of the coast it arrests the eye with many converging facts which lengthened descriptions would fail to convey. It is almost a waste of argument to explain what is so clear, and yet one is tempted to reiterate some of them with a few words of explanation and enforcement.

1. The greater part of the tonnage from San Francisco to the northward goes direct to the Columbia River and to the Strait of Fuca, but the greater number of the vessels goes no farther north than Crescent City. Between Crescent City and the Columbia River there is a very small amount of trade.

Now, as those vessels that trade to the northern ports are larger, better found, and manned, and keep a larger offing, they have less reason to resort to a harbor of refuge than smaller vessels have. If their necessities demand a harbor of refuge it should be well advanced in the winter storm region, accessible, and free from dangers of approach, free from dangers in leaving, and especially free from dangers if the harbor is missed in attempting to reach it. On the other hand, the vessels that trade to points no farther north than Crescent City are of a smaller class, are usually not so well found or manned, and generally keep close along-shore. Very many of the smallest of them trade to the lumber-chutes northward of Bodega Head, and take unusual risks at such places; but, as the table shows, this special division of the traffic is very limited in the winter season, although the amount for the rest of the year is very great. Even if we look at the traffic from San Francisco to points between Point Reyes and Shelter Cove, we find no less than 53 per cent. of all the sailing-vessels and 17 per cent. of all the tonnage carried on within that short stretch of coast. Nevertheless, it would be unsafe to affirm that this percentage can be maintained for many years, for the lumber supplies must in time decrease, and with it the shipping now enjoying that trade; other developments may, however, help to supply that special decrease.

I think the whole trade hence to points as far north as Crescent City or Port Orford must always be a comparatively large one, and a fair percentage of it is carried on within the limits of the heavy storm region.

If protection is to be afforded to traffic carried on under disadvantages, such as we have enumerated, the location of the harbor of refuge should be southward of Crescent City.

The tabulated wreck statistics show the total and partial losses without specifying the causes, whether from collision, fire, unseaworthiness, stress of weather, or running on rocks. Many of the causes of such losses could not have been averted by a harbor of refuge. To have been complete it is granted that the division should have been made for causes, for sailing-vessels and steamers, for seasons, &c.; but this was not wholly possible with the data available.

As it stands it shows that only 31 per cent. of the total and 23 per cent. of the partial losses occur in the traffic to the Columbia River and Strait of Fuca, whereas it will be noted that the traffic hence was 68 per cent. by sailing-vessels, and 76 per cent. by steamers; whilst hence to ports as far north as Crescent City there was 47 per

cent. of total and 38 per cent. of the partial losses, although the amount of traffic was only 25 per cent. by sailing-vessels and 16 per cent. by steamers.

The question of the location of a harbor of refuge should be settled mainly upon the necessities of commerce; but as the possible locations are comparatively few, I mention the various points which have been suggested, and at the same time add to and reiterate some of the foregoing statements; this will naturally bring the engineering phase to bear upon the solution of the problem.

1. *Neah Bay inside the south side of the entrance to the Strait of Fuca.*—It affords a moderately good anchorage for all vessels in southeast weather; but a large swell sometimes rolls in here, and vessels anchoring far in to avoid the swell encounter risks in getting out if the wind suddenly veers to the northwest. In my own experience I have preferred to encounter a week of heavy southeasters outside to lying here. When the storm was over I had a good offing and a strong northwester.

2. As I have elsewhere mentioned, *Destruction Island* was examined to determine its availability for affording a protection for a vessel under stress of weather. With our present knowledge of its dangers it may be set aside.

3. *Off the mouth of the Columbia River 46° 12'.*—This would demand a gigantic undertaking, for which we have no reliable data. But it seems to me safe to say that, should it be practicable to construct a great breakwater outside the middle sands, in 10 or even 12 fathoms of water, the silt from the river would be much more certain to shoal it than has been done at the Delaware Breakwater. It would be the barrier against which the great and never-ending amount of matter in suspension brought down by the Columbia River would be carried by the strong outgoing current of this large river. A preferable location would be abreast of Tillamook Head, projecting the breakwater directly into the sea if the depth of water permitted.

In this latitude a harbor of refuge would be available for very few vessels, except those trading solely to the Columbia. Vessels bound for ports further south, such as Port Orford or Crescent City, would not use it on account of its great distance; and those bound for the Strait of Fuca would run to get inside of Cape Flattery.

4. *Yaquina River, latitude 44° 36'.*—The reef off the mouth of the Yaquina has been proposed as the backbone of a breakwater. It runs parallel with the coast line, and there are hardly any conditions which would warrant its being utilized. It forms a species of natural breakwater to the entrance to the river against the westerly seas; but inside this reef the channel-way running north and south for about a mile is only one-quarter of a mile in width, with but 3 to 5 fathoms of water, and it would, therefore, form but a limited harbor of refuge. In heavy weather the water must break from the south end of this reef to the breakers lying  $1\frac{1}{2}$  miles to the southward, because there is only from 3½ to 6½ fathoms on the line between them; therefore the approaches would be dangerous in the extreme. The line of breakwater would be in the worst possible direction for the destructive action of the winter storm waves.

5. *Cape Gregory, latitude 43° 21'.*—This is the only point of the extended coast line where the trend of the shore line is such as to afford any protection whatever in southerly weather. Officers of the Hudson Bay Company and of the Russian-American Company informed me, years ago, that their vessels have anchored here in heavy southeast gales, and it was reported that the light-house steamer Shubric had anchored here in a southeast gale in 5 fathoms close under the head, putting to sea when the wind shifted to the westward. This position may be considered as well advanced into the stormy region of the north. There are no dangers to its approach nearer than the Orford Reef, 35 miles to the southward. It will be adverted to hereafter.

6. *Port Orford, latitude 42° 44'.*—This is the best summer anchorage on the coast, but it is broad open to the storms of winter. We were stationed here three months in the winter season of 1851-52, and experienced some heavy weather, when a "terrible sea rolled in that no vessel could have ridden out." It is located near the extreme western limit of the coast hence to Cape Flattery, and if a breakwater were constructed here it would be available for all vessels making the higher northern ports, but a vessel to the northward of it could not make it in winter, and it would be hazardous for a vessel in distress to attempt to reach it. It is well marked, and may be said to be free from dangers in approaching it from the southward, the nearest danger being the reef off Rogné's River, 15 miles to the southward. A vessel in distress making for this harbor in heavy southeast weather, and missing it must go through the Orford Reef and very largely increase her risks. This port will be referred to again.

7. A point for a harbor of refuge has been mentioned near *Mack's Arch*, about latitude 42° 15' but it is very contracted and exposed. It may be dismissed.

8. *Crescent City Bay, latitude 41° 45'.*—This, even as a summer anchorage, is "the most dangerous of the roadsteads usually resorted to on the coast." "It is filled with sunken rocks and reefs, with a goodly number showing above water. No vessel should think of gaining an anchorage here without a pilot or a perfect knowledge of the hidden dangers" (Coast Pilot, page 106.) I have no reason to change my judgment in this description. Even granting that a breakwater might be built here, the harbor would be contracted and full of dangers; moreover, if a vessel, disabled or otherwise,

were to seek refuge here in a southeaster, and by any unforeseen circumstance miss her port, the dangers of the lee shore for 4 miles from the light-house to Point Saint George, and the Dragon Rocks stretching 7 miles farther to the northwest, would vastly increase her chances of destruction, although there are two passages of 10 to 12 fathoms through the reef.

9. *Trinidad Bay, latitude 41° 03'.*—"The bay or roadstead of Trinidad is very contracted, but having deep water and all dangers visible, forms a moderately good summer anchorage." (Coast Pilot, page 103.) This bay lies 38 miles north and 13 miles east of the great bend of the coast at Cape Mendocino, and may be reckoned near the southern limit of heavy winter weather. "In winter it is a dangerous anchorage, and if a vessel is unluckily caught, her chances of riding out a southeaster are very few."

There are no outlying dangers to the southward nearer than Cape Mendocino, although a shoal patch with as little as  $6\frac{1}{2}$  fathoms of water lies seven-eighths of a mile southwest of the Pilot Rock. To the northward the immediate coast for 5 miles is bold and rocky and trends to the northwest, so that a vessel missing her port in winter might weather it, unless the weather should be very heavy and the swell come in from the west-northwest, as is claimed. This bay will be again referred to.

10. *Shelter Cove, latitude 40° 01'.*—"This contracted summer anchorage lies south of what may be considered the heavy winter storm region. We have not an extended detailed hydrographic survey of this locality, and yet the indications of the preliminary survey are favorable for the location of a breakwater in 10 fathoms, which would afford a good harbor of refuge in winter storms for all the small craft trading to the anchorages and chutes between Point Reyes and this place, and incidentally for those of the same class trading farther north. Any of these smaller vessels seeking a harbor of refuge would avoid the dangerous and heavy seas off Cape Mendocino if compelled to run to a harbor north of that cape. The adjacent shore is very high, and material could be very readily obtained.

11. *Drake's Bay, latitude 37° 50'.*—"This harbor, only 27 miles from San Francisco Bar, is frequently used for refuge by small vessels waiting for better weather to cross San Francisco Bar, or to continue their voyage northward. The anchorage is in 4 fathoms, close under the eastern point of Punto de los Reyes, and is of limited area. A breakwater carried due east from the eastern point of rocks into 10 fathoms of water would afford capital protection for a large number of vessels. With these remarks it may be dismissed for our purposes.

Of the localities thus chiefly specified, the three points that more particularly merit attention are, Trinidad Bay, in latitude 41° 03'; Port Orford, in latitude 42° 44'; Cape Gregory, in latitude 43° 21'. Of these I should reject Port Orford for the following reasons:

The sea that rolls square into this roadstead in winter is very heavy. I vividly remember its terrific force in the prolonged gale of December, 1851.

The deep water comes quite close to the southern face of the western head. Therefore, to construct a breakwater that should afford a reasonably capacious harbor of refuge, it would be necessary to carry it through excessively deep water. If laid in 10 fathoms of water, the area of the harbor would be very limited, and only accessible at the eastern or shore end. This last condition would involve risk in a vessel entering, because the passage-way between the eastern extremity of the breakwater and the shore would be very narrow, and the safety limits of this passage would be still further decreased if the sea breaks in 7 or 8 fathoms or more. My personal recollection of the direction of the wind here in winter storms is that it comes from the south, and that the swell comes from a little west of south, say south-southwest.

To give adequate anchorage and fair access to a harbor of refuge here, the breakwater should be located in 13 to 12 fathoms of water, and be disconnected with the shore at the western extremity. It should start in 13 or 14 fathoms from a point about one-quarter of a mile magnetic east from the northern part of Tichenor's Rock, and run three-quarters of a mile magnetic east to 12 fathoms of water. This would give an entrance of one-quarter of a mile wide between Tichenor's Rock and the western extremity of the breakwater, with 10 to 13 fathoms depth, and also an entrance of one-half mile and over to the eastward of the eastern extremity.

This would involve an enormous cross-section and vast expense. Hesitation might well be felt in undertaking it. The trestle-work for carrying the material from the rocky cliffs to the site would doubtless be destroyed in winter, unless the season should be exceptionally favorable. It might be made of iron screw piling or iron piling secured in part on Tichenor's Rock. If open and in the right direction to receive the swell, it would probably withstand moderate winter weather.

As the locality is well situated in regard to the trend of the coast, it would appear to be available for all vessels disabled or seeking a port between Mendocino and Orford; but on account of the existence of the Orford Reef, lying immediately to leeward, a vessel missing the port in heavy winter weather would be in the greatest jeopardy. It is true there is a channel-way through the reef, but in heavy ground swells from the northwest it is asserted that it breaks nearly across this channel;



even if it did not break across in southeasters, thick or dark weather would render its passage hazardous, especially as a vessel is supposed to be disabled or under stress of weather in the act of seeking such refuge.

The existence of the Orford Reef in this relation to the proposed harbor of refuge presents an almost insuperable objection in my mind. The location is well advanced into the stormy region, and, therefore, has some claims; but it is not so far advanced as Cape Gregory. On the other hand, it is too far advanced to be of use to the great numbers of smaller craft making short passages, and in this respect a more southern location would have the advantages.

This brings me to the consideration of the two locations, Trinidad Bay and Cape Gregory. And here are several conflicting conditions to be settled before a final decision can be fairly arrived at.

Much can be said in favor of Cape Gregory, mainly because it is well advanced into the storm region, in fact farther than any as available point; and also because it is in fact a small natural roadstead against southeast storms. It has long since been utilized as a harbor of refuge, as mentioned in the Coast Pilot, page 120, 3d edition. There are no dangers of approach or of leaving; and when the storm is veering round to the southwest, west, and northwest, there would be little difficulty in getting to sea. A disabled vessel missing the port would have no dangers under her lee. With a broken line of breakwater of 5,000 feet in length, the area for refuge would be larger than at any other locality. And a disabled vessel in strong summer winds would find ample protection under the breakwater.

I believe the northern trade will increase steadily and surely, and perhaps in a greater ratio than the traffic to all the ports lying between San Francisco and Crescent City. The amount of the trade, as exhibited in the table of statistics, is the strongest claim that can be put forward for a high northern port of refuge. Of the whole tonnage by sailing vessels between San Francisco to all northern ports in 1878, there was to the Columbia River and the Strait of Fuca 68 per cent. of the tonnage and 25 per cent. of the vessels, and of the total tonnage by steamships 76 per cent. of the tonnage and 42 per cent. of the vessels. If we include the traffic as far south as Crescent City these percentages are increased 7, 9, 9, and 16 per cent., respectively. From this point of view alone the claim to location at Cape Gregory is very strong; and it is increased by reference to the wreck statistics, which show that in the traffic between San Francisco and all points from Crescent City to the northward the percentage of total losses is 53 per cent., and of the partial 62 per cent.

These are strong arguments in favor of a port as high as Cape Gregory. But such a port of refuge would not be available to the smaller vessels trading to the lower ports unless they were to run a very great distance out of their way and necessarily in very heavy weather. And again, it must be acknowledged that several of the largest wrecks which swell the percentages above quoted arose from collisions, or from circumstances which would have precluded the vessels availing themselves of any port of refuge.

The traffic to these northern ports is, as we have already shown, carried on by large and generally sound ships that keep a good offing, and would, unless in exceptional cases, keep the sea in bad weather.

Of the character of the rock composing the high lands of Cape Gregory, I am not competent to judge whether it would be satisfactory for the construction of a breakwater. Without doubt it may be obtained in large masses by quarrying, and can be moved by gravity to the works. Even if not of hardness sufficient to withstand extreme wear, it might still form the great bulk of the breakwater, which could then be covered on the foreshore with harder material.

If the eddy shore current is here moving to the northward or to the southward it would be necessary to keep open a space between the southern end of the breakwater and the cape. In its construction the staging, for carrying the railway tracks from the cape to the site, would be perhaps more liable to damage at this locality than at Trinidad Bay.

*Trinidad Bay, latitude 40° 03'.*—This locality has certain advantages, differing in character from those of Cape Gregory. It is near the southern limit of the winter-storm region, and therefore not so subject to the prolonged heavier weather farther north, although, as we have elsewhere shown, the swell at Cape Mendocino, only 38 miles to the southward, has been seen to break in  $9\frac{1}{2}$ ,  $9\frac{1}{2}$  fathoms of water, and vessels have been lost in endeavoring to ride out a southeaster here. Nevertheless, the trade from San Francisco to Humboldt Bay indicates that the winter weather is not feared as it is farther north.

There are no outlying dangers to the southward nearer than Blunt's Reef off Mendocino, although a shoal patch with only  $6\frac{1}{2}$  fathoms of water lies about a mile southwest of the Pilot Rock. The dangers to be feared, if a vessel missed the harbor in southeast weather, do not stretch out as at Crescent City and Port Orford Reefs, but the coast, closely bordered by rocks, stretches for about 5 miles to the north-northwest, and a vessel might weather it unless she were in distress, or if the gale should

be very heavy with the swell coming from the west-northwest, as has been affirmed. There would be no immediate dangers inside within a reasonable distance of the breakwater.

But the principal claim for a harbor of refuge here must be based upon the tabular statistics of the traffic north of San Francisco; upon the permanency of this traffic; upon the deductions derived from these and the wreck chart; and upon the general character of the vessels engaged in the trade to these way ports.

If we assume that the traffic between San Francisco and ports south of Crescent City will gradually increase, notwithstanding the more than probable decrease of the lumber traffic from the coast chutes; and if this trade will continue to be carried on in the smaller class of vessels, we may, for our present purpose, assume that the ratio of losses at sea will be as great as in the past. And we have already seen from the wreck chart that 47 per cent. of the total losses and 38 per cent. of the partial losses occur on this stretch of coast line, although the amount of commerce was only 25 per cent. by sailing vessels and 16 per cent. by steamers.

This stretch of coast has, therefore, a strong claim for a harbor of refuge, whilst the claim is necessarily strengthened (as any other point would be, however) by being in a measure available up to that latitude, for all vessels trading to points north of it. I qualify the availability because the more northern-bound vessel keep a greater offing.

It is granted that a line of railroad carried along the immediate coast line, and tapping all the small valleys for produce, and all points for lumber, would necessarily destroy much of the carrying trade by vessels. But the physical difficulties to the construction of such a road along a peculiarly difficult part of the coast, sparsely populated and developed, must for a great many years prevent more than the conception of such a scheme. On the other hand the country immediately bordering the coast has been steadily developed, and the larger valleys are increasing in population and coming into cultivation.

Whilst I look forward to a steadily increasing traffic to all parts of the northern coast, I think the ratio of increase will be the greater north of Cape Mendocino.

The first suggestion for the site of a breakwater at Trinidad would doubtless place it in such a position that Pilot Rock would be at the angle of the broken line. In which case a line of about 5,000 feet would inclose about three-fourths of a square mile within the 5-fathom line, although all of that space would not be fully and wholly protected.

It has been found in every case that the harbors of refuge have all proved too small within a few years of their construction; and, moreover, in this location the line would be built in from 9 to  $8\frac{1}{2}$  fathoms of water, which, I think, is not deep enough. I should project the broken line about one-sixth of a mile outside of Pilot Rock, commencing the western point in the 10 fathoms of water, and on the eastern extremity ending in about 9 or  $8\frac{1}{2}$  fathoms. A vessel could enter from either end of the breakwater.

In this place, as for any other, there is demanded an exhaustive study of the general and local currents; their effect upon the sands of the shore to the southward, the direction and force of the swells of summer and of winter, the direction of the storm winds, the possibility of a disabled vessel weathering the rocky shore to the north-northwest if the port is missed, the best construction of staging for the tramways carrying the materials, &c.

The thorough survey of the bay by the Coast and Geodetic Survey is all-sufficient for purposes of location so far as depths and dangers are concerned, but the study demanded for the other specified conditions of the problem should be prolonged through not less than a year, and might profitably be carried through two winter seasons.

The preponderance of claims for the location of a harbor of refuge, as between Trinidad Bay and Cape Gregory, based upon the tonnage traffic, disasters, latitude, and natural and local advantages appear in favor of Cape Gregory.

I do not forget that the size and the character of the vessels and of their outfit is favorable to their weathering winter storms, but the storms are heavier; nor that very few vessels would be in a position to seek a harbor of refuge when once north of the port, nor the fact that unless the existence of the harbor should change the views of navigators most of them would prefer to keep the sea unless hopelessly disabled. Nor do I overlook the fact that the basis of disasters is in part delusive, because a large percentage of these arise from collisions, &c., yet this may apply to any location whatever.

The amount of information which we have at present of the engineering advantages and difficulties is very limited. In the difficulties are included the greater depth of water, the greater storm waves of winter and their direction when attacking the breakwater, the action of the summer northwest swell upon the structure when being built, and the direction of the shore current involving the movement of the sands there existing and those brought down by the river waters. These unsettled engineer-

ing questions certainly add doubt in forming a final judgment, irrespective of the commercial view.

The claims of Trinidad Bay are less than those of Cape Gregory on the score of traffic and disasters and are greater as to the number and character of the vessels employed. Viewed simply from the percentages of the tables, Trinidad would have a second claim, but weighing the size and character of the vessels employed and their outfit, which are certainly inferior, it seems fair to admit that the claim may be advanced to equality with that of Cape Gregory.

Moreover, our information of the engineering phase of the problem is here somewhat better than at Cape Gregory. I believe that the breakwater would be built in a direction better suited to withstand the destructive action of the southeast gales; the destructive agency would also be less on account of its more southerly position and the character of the bottom to windward. The cross-section would be less, although its area cannot be foretold. But we do not know with certainty the direction and relative force of the winter storm-swells, nor the precise movement and action of the local current.

Upon the general question of engineering in building a breakwater at Trinidad Bay and at Cape Gregory, the present known advantages are in favor of Trinidad.

In my examination of the subject of a harbor of refuge, I have left out of consideration the prospective advantages of development that might possibly accrue to any particular section of the coast country or to any particular interest by the construction of a breakwater at any given locality.

If the breakwater could be constructed at the most forbidding part of the coast line and yet fulfill all the conditions of a harbor of refuge as such, no other question should be allowed to militate against it.

Where such interests are involved and such a large amount of money will be necessary for the construction and maintenance of the works, and where so much more positive information should be gathered, I am constrained to say in conclusion that the whole problem is not yet in a condition to warrant a final judgment. The claims of Trinidad Bay and Cape Gregory are in my mind very evenly balanced, and I believe it is yet necessary and imperative to have made a thorough and exhaustive examination and study at each locality of all the physical conditions involved through a period of perhaps two winter and one summer season.

I append a few remarks upon the form, &c., of breakwaters, basing my opinions upon personal examinations which I have made.

Yours, respectfully,

GEORGE DAVIDSON,

*Assistant, United States Coast and Geodetic Survey.*

ADDENDUM TO LETTER OF APRIL 20, 1880, ADDRESSED TO COLONEL STEWART, UNITED STATES CORPS OF ENGINEERS.—CHARACTER OF THE BREAKWATER FOR PACIFIC COAST HARBOR OF REFUGE.

The questions that naturally arise as to the character of the breakwater to be built at any given point cannot be satisfactorily answered until it is decided *where* the harbor of refuge is to be established. And then prolonged and exhaustive detailed examinations must be made upon the conditions of the local and general currents of the harbor through perhaps two winter and one summer season; the peculiarities of the storm waves as to direction, intensity, height, and volume; the direction, force, and changes of the storm winds; the quality of the rock to be used; the means of carrying and depositing it where it is demanded, &c.

It would be almost futile to attempt a plan upon the general and vague information elicited from parties locally interested in the different places suggested for a harbor of refuge, or even upon examinations made in summer weather, and if a locality be decided upon, I think that the considerations suggested in the preceding paragraph and many others that incidentally arise should be faithfully investigated, and then a final judgment formed upon the feasibility, suitability, and adaptability of the place for a breakwater, and upon the character of the structure.

I am, at this time, of the opinion that a breakwater, *à pierre perdue*, can be constructed at any point available on this coast; and that the general principles demonstrated in the *storm-developed cross-section* of the Portland and Holyhead breakwaters should be the basis of construction. I have adverted to this in my short report to the Superintendent United States Coast and Geodetic Survey, "Observations on certain harbor and river improvements collected on a voyage from Hong-Kong, via Suez, to New York;" and to this date I have seen no reasons to change my opinions.

There can be no reasonable doubt in the question of quarrying and placing in position the largest possible masses of natural stone demanded for the purpose. I think the expense of manufacturing great masses of artificial stone need not be incurred, un-

less they can be cheaply and easily formed of the smaller pieces of the quarried rock at the point. These may be adopted if sufficiently hard to withstand the wear and tear as well as the natural rock.

In a breakwater *à pierre perdue* we learn, from the utter failure at Alderney, not to use material of such small size as was there used. What I saw and reported upon the beton blocks *à pierre perdue* at Port Said, and the beton blocks laid as a wall at the North Sea entrance to the Amsterdam Canal, makes me doubt the durability of beton. The cost of such a breakwater as the Admiralty Pier at Dover would be incalculable on this coast, and it would be very difficult to find such a favorable bottom for the foundation as exists there. The similar attempt at the North Sea harbor is an engineering failure on this account.

As a question of engineering, without regard to cost or time, I believe the vertical wall, such as the Dover Pier, is the best for a breakwater; but the highest engineering is only the best common sense in a commercial point of view, and that demands the smallest cost and the least time, combined with the greatest safety in such a construction.

One point of special interest in the site and construction of a breakwater is the character of the current moving the material at the bottom. I have elsewhere shown that there is an eddy current running northward close inshore and affecting all, or nearly all, the entrances to bays and rivers on this coast. This current may at times be temporarily overcome by the prevalence of heavy northwest weather, especially off the prominent headlands; at other times it extends far outside these capes. I have determined its width off Cape Mendocino, after a week of quiet weather, to be as much as 15 miles, with a movement of  $1\frac{1}{2}$  miles per hour. It has been proved to exist as far north as the northwestern extremity of Vancouver Island. Its general effect is seen in the direction of most of the channels to the bays and rivers running directly into the face of the northwest swell and the northwest wind; and the southern points of bays stretch well to the northward and westward when composed of the sand moved by this eddy current. Even the bar of San Francisco is a good example of its persistent force, for here we have a subsurface point stretching from the south side of the entrance well to the westward and northward, whilst the deepest channel is close under the north head. At Humboldt Bay the normal direction of the channel is to the northward and westward, and sometimes it runs very close under the north shore; and even at Coos Bay the same general direction of the channel is more marked, for in some seasons the channel runs northward very close under the north shore. If this eddy current did not exist these conditions would all be modified. If the shore current at Coos Bay entrance were from the northward, we would naturally expect that this force, combined with a northwest swell and a northwest wind, would crowd the channel close under the south shore towards Cape Gregory.

When some of the short-course coast streams are closed at their mouths in summer, such as the Russian River, the Walalla, Cheteo, &c., the last point of closing is under the north head, indicating that the material is moving northward. To the California Academy of Sciences I have frequently given extended proofs of the existence of this current, and advantage has been taken of its effects in the construction of the jetty in the bay of San Pedro.

This movement of the material along the bottom close inshore must enter as an important factor in the construction as well as in the location of a breakwater. If the artificial harbor were closed at its western extremity by the breakwater joining the shore, there would certainly follow a silting of the harbor. It is therefore necessary to construct the breakwater free at the western extremity, and this condition increases the difficulty of construction, and affects the size of the cross-section at that point.

Another very important element that must in a great measure affect the form and size of the breakwater depends upon the direction, volume, and force of the swell rolling into the roadstead, and the depth of water in which the swell breaks. Although I have from the summit of Cape Disappointment frequently watched the break around the bars of the Columbia River from the cape to Point Adams, and of San Francisco Bar from the south beach to the west side of the Boneta Channel, and have crossed both these and other bars breaking, I cannot state precisely the depth of water in which the swell breaks. My opinion is that I have seen it breaking in from 7 to  $7\frac{1}{2}$  fathoms of water. The largest swell I ever saw on the coast line was a northwest swell, rolling in very regularly upon Cape Mendocino without any local wind. It enabled me to see seven or eight breaks or sunken rocks, until then not seen or located. But one of the Coast Survey officers subsequently stationed there in winter to watch for other breaks saw the southwest swell breaking over a moderately large area, where we know there is  $9\frac{1}{2}$  to  $9\frac{3}{4}$  fathoms of water at low water without rocks. There was at the time no local heavy wind to raise white caps and confuse the judgment; and this heavy swell showed other breaks upon sunken rocks not seen in the northwest swell.

So far as my knowledge goes, this is the deepest water where the Survey has observed the water breaking on this coast; and it is valuable as being observed by an



officer thoroughly competent to judge, over a locality accurately sounded out the previous season, and with the attendant circumstances peculiarly favorable.

Knowing these facts, and weighing them with others, I have heretofore expressed my conviction that a breakwater on this coast should not be built in less than 10 fathoms of water, and I see no reason to modify it except for these cases. In such a locality as Port Orford or Coos Bay, both well advanced into the winter-storm region, with very large swell, I would carry the breakwater into 12 fathoms of water. In such a locality as Trinidad Bay, where there is a long approach of comparatively shallow water, the breakwater may be constructed in about 10 fathoms, decreasing at the eastern extremity.

GEORGE DAVIDSON,  
*Assistant, Coast and Geodetic Survey.*

LETTER OF MR. AUG. F. RODGERS, ASSISTANT, UNITED STATES COAST AND GEODETIC SURVEY.

UNITED STATES COAST AND GEODETIC SURVEY,  
*San Francisco, Cal., January 10, 1880.*

SIR: I have the honor to acknowledge the receipt of a circular letter, addressed to myself and other officers of the Coast and Geodetic Survey by the recorder of the Board of Engineers for the Pacific Coast, requesting an expression of opinion regarding the location of the proposed harbor of refuge on the Pacific coast south of the Straits of Fuca.

I have the honor to submit to the Board the following conclusions at which I have arrived, after careful consideration of the several questions involved, among which I may name as most important, first, the geographic formation of the coast, relative to natural harbors; second, the meteorology of this section of coast, to which the inquiry of the Board of Engineers is directed; and, third, the routes of commerce now existing, and the future probability of change.

I will only briefly mention that well known geographic feature of the Pacific coast, which, perhaps, more than any other consideration, seems to suggest the necessity of a harbor of refuge, viz, that between the Straits of Fuca and the entrance to the bay of San Francisco there is not a single harbor of safe access, to a vessel in distress, during the southerly gales of winter. The distance named covers nearly  $11^{\circ}$  of latitude; within that distance we find numerous summer anchorages, most of them accessible to vessels of all classes when the winds blow from the northwest, the north, the northeast, or the east, but unsafe anchorage for any class when the winds are from the southeast, the south, or the southwest. The first-named directions of the wind refer to a climatic period of about 5 months' duration, commencing in June and ending in October; the latter to a period of 7 months, commencing in November and ending in May.

Nature has thus provided half of a good harbor at several points on the coast between San Francisco Bay and the Straits of Fuca. Among these I name only those which have attracted most public attention as suitable for the proposed harbor of refuge, viz, Cape Gregory, at the entrance of Coos Bay, Port Orford, Crescent City, and Trinidad.

It is here important to note that the asserted claims in favor of Cape Gregory are based upon a fact exceptional to all the others in its affording by natural formation partial protection from the southward, while it is open to the northwest winds.

Referring briefly to the meteorology of the coast as bearing upon the question of a harbor of refuge, it will be sufficient to say that the two climatic periods, already incidentally referred to, are radically distinguished from each other; that one commencing in June and ending in October being marked by an equal barometric pressure and absence of rainfall; by northwest winds usually strong during the days, and light at nights, and when the direction changes to the southward the force would usually be expressed by the term "light airs." This period, though exempt from storms, is marked by the prevalence of heavy fogs, which may, perhaps, be justly considered a source of greater danger to the mariner than all other natural causes combined. During this season fog-whistles are in much greater demand than harbors of refuge, unless in cases of unforeseen emergency.

The other climatic period, commencing in November and ending in May, is characterized by a varying atmospheric pressure, by copious rainfall, increasing in quantity towards the northern portion of the section of coast under consideration, alternating in fair weather and light variable winds and strong gales from the southeast and southwest; these gales are accompanied by rainy, thick weather, but are usually preceded from 24 to 48 hours by a heavy ground swell setting in from the westward. When this swell commences, vessels at anchor in the northwest harbors, or those safe from May to October, are obliged to get under way and stand out to sea, where with

a good offing from the coast they must wait the breaking of the gale. Vessels are thus liable to be caught at any stage of the process of loading or unloading, and are often forced to go to sea unprepared. It is during this period of 7 months that a harbor of refuge would be of service to the coast fleet, and occasionally to deep-sea vessels in the foreign trade.

It must be further remarked that all the winds of the Pacific coast region under discussion blow at such an angle with the general coast line that any seaworthy vessel, with a fair offing, can work off or away from the land. This fact, viz, that except to a vessel locally embayed the coast is never a lee shore, while diminishing the necessity of numerous harbors of refuge, gives to disabled or distressed vessels many more chances of utilizing such a general harbor of refuge as may be located with reference to the most active routes of commerce.

Bearing upon the question of the existing routes of commerce and the probability of future change, I have the honor to call the attention of the Board of Engineers to the accompanying tracing, the shore line of which is copied from the charts of the Coast and Geodetic Survey. Upon this tracing I have endeavored to show graphically by co-ordinates of departure and destination the present routes of commerce, data for which had been carefully collected from the daily press reports for the year 1878-79.

For the sake of perspicuity I have divided this coast line, as shown upon the tracing, into two approximately equal sections; the northern one I refer to as the Straits of Fuca section, the southern one as the San Francisco section.

It is well known that the coasting trade north of San Francisco makes San Francisco Bay the objective point of arrival and departure on each successive trip; that all coasting vessels to the Straits of Fuca leave from San Francisco Bay and return in regular trips, and that the same is true of the coast trade to the Columbia River and to Coos Bay and to all other points on the north coast between San Francisco and the Straits of Fuca, and that there is no intermediate trade between these several ports. It follows, then, as a necessary consequence, that vessels bound to the most northern port or the entrance to the straits spend *half* their sea time in each section, as delineated on the accompanying tracing, and that the portion of the sea time spent in the San Francisco section increases proportionally as the northern port of destination is south of the straits and nearer to San Francisco.

This appears conclusive, if so much of the coasting trade as sails north of the San Francisco section, as shown on the tracing and the statistics upon which its graphical illustration is based, show a large preponderance of numbers confined to the San Francisco or southern section. Of the future it seems safe to say that we must find many vessels then, where we find one now, and that therefore, even if comparative changes do occur as to the volume of trade at particular ports, no such change can take place as will impair the usefulness of a harbor of refuge so located to-day as to best meet the requirements of the greatest number of vessels.

If doubts suggest themselves as to future development and growth of this great Western Empire stretching from Arizona to Alaska, they must be resolved if we remember that the present development of California not more than equals the age of one generation of men; that the area of the State of California equals that of New York and Pennsylvania and all of New England combined; that it is peopled to-day by less than one million souls. Inclosing an area of 120,000,000 of acres, only 4,000,000 are as yet under cultivation.

Admitting anything adverse opinion may suggest, these main facts require no argument to re-enforce them. San Francisco Bay is situated in the center of the seaboard of this great region, abounding in mineral and agricultural wealth, without the possibility of a commercial rival within distances which reach to San Diego on the south and the Columbia River on the north. Within these distances of 500 miles on either side, San Francisco Bay offers the only possible entrance and secure harbor to vessels of all classes during all weather.

I forbear to pursue further this topic. The considerations I have named seem to me ample to suggest the conclusions to which I have already adverted.

As a general principle referable to the Pacific coast, it may be asserted that any harbor of refuge located with regard to the interests and security of any port or fleet should be placed to the northward of that port or fleet, for the reason that the so-called storm winds are always from the southward, while the return of fair weather is marked by northwest and northerly winds. In other words, the storm-bound vessel or fleet should be able to run to leeward for safety, and in case of a severe gale or in a disabled condition no other course would be practicable. I call your attention to this fact and to one special to the present condition of the coast commerce of the Pacific between San Francisco and the Straits of Fuca, viz, that the coasting fleet of these two sections is divided both by distance and character. The San Francisco section reaches its maximum northern point of development at Humboldt Bay, while the Straits section makes its southern maximum at Coos Bay or Cape Gregory. The distance, 150 miles, between Humboldt and Coos Bay is a comparatively undeveloped region; a harbor of

refuge within this area would be of use to San Francisco section, but practically useless to the Straits section if the assumption is true that a harbor of refuge should be north and to leeward during southerly gales of the fleet to be benefited by it. I am forced to the conclusion that if a harbor of refuge is needed on the Pacific coast, that the vessels of the San Francisco section and the Straits section are so widely divided in distance and in their character, their sailing routes so different, that it would be impossible to so locate a harbor common to both as to be of common benefit. On the contrary, a harbor so located would be resorted to for refuge only by such passing vessels as might by fortuitous circumstances need its protection at the time of passing during storms; vessels from the San Francisco section could not run to leeward the 400 or 500 miles necessary to reach a refuge best located for the requirements of the north fleet, and if located with reference to the requirements of the south fleet, all of the sail vessels of the northern fleet caught in a gale of wind north of the harbor would be obliged to keep the sea as they do now without regard to emergencies. In this view I suggest that a harbor of refuge for the San Francisco section should be located at some point in the northern portion of that section, and for reasons which I think will be apparent from further considerations, a harbor so located will best subserve the present interests and the present development of the coasting commerce of the Pacific. If further developments should render a second harbor of refuge necessary north of San Francisco Bay and near the Straits of Fuca, I think it should be north of the straits and upon the shores of Vancouver Island. I am aware that such a location would involve international questions beyond the scope of present discussion. I make the assertion only as illustrative of the general principle of the necessity of locating harbors of refuge to leeward, during southerly gales, of the fleet to be benefited.

Before proceeding to discuss the different locations proposed for a harbor of refuge, it may be proper to remark specially upon the first and greatest requisite in such a harbor in natural features. The first requirement is unquestionably in *general safety of approach from seaward*, not in the approach from one direction only, but in all directions as referred to the adjacent coast, for it must be remembered that the greatest risks of the mariner commence when he approaches the land with his vessel, risks often arising from mistaken reckoning, from mistaken land falls, from fogs, from rainy thick weather, and from dark nights; that the greatest number of wrecks occur not from stress of weather in open ocean, but in approaching and leaving even the best natural harbors. We need go no further than the trade of the Pacific and San Francisco harbor records to see this illustrated. This question, then, of safety of general approach must be considered the first and greatest requisite in a harbor of refuge. The comparative fitness or unfitness of any immediate locality in natural formation, however important, is subsidiary to that of general approach, as being much more within the control of the engineer.

Turning to the several locations prominently mentioned as suitable sites for the proposed harbor of refuge, I take Cape Gregory as the most northern, and to this, whatever the claim in its favor, the obstacles to its usefulness seem to me almost insuperable, the reef of rocks upon which a breakwater would be naturally based closes to the southward. Harbor lines suggested by the natural formation must be so close to the beach that the anchorage ground would be of very limited area, and this area so close to the embouchure of Coos Bay as to be a probable receptacle and settling reservoir for the major portion of the sediment discharged from that bay on each ebb-tide.

Natural formation at Cape Gregory would enforce the projection of harbor walls in such form that it would be difficult for a storm-beaten vessel to enter in a southerly gale, difficult to make a safe departure with the northwest winds, which usually on the Pacific coast mark the change from foul to fair weather. I think that Cape Gregory as a general harbor of refuge has no good claim to consideration.

Port Orford is one of the best and most commodious summer roadsteads on the Pacific coast. Its geographical location is approximately half way from San Francisco to the Straits of Fuca, on the dividing line between the San Francisco Bay and Straits of Fuca sections, as referred to herein and shown on the accompanying tracing. Port Orford as a site for a great commercial harbor to supplement the natural deficiencies of the Pacific coast in respect to harbors would be geographically perfect, but as a harbor of refuge, where the storm-strained vessel may seek an anchorage in all weathers, it has objectionable features in dangerous outlying reefs, flanking its approach from the north and south. Orford Reef and Blanco Reef on the north, and that of Rogue River on the south would be practicable "dead-falls" to the mariner if he should be forced to seek a harbor of refuge at Port Orford during the fogs which prevail in summer or in the thick weather accompanying southerly gales of winter on the Pacific coast.

The next roadstead south of Port Orford is Crescent City; the approaches to this from the north are cut off by a dangerous reef. Saint George's Reef is memorable in the annals of the Pacific coast as the site of the wreck of the steamer Brother Jonathan, involving the loss of many lives, among them, that of Gen. George Wright and other officers of the Army. A harbor based on natural facilities at Crescent City

would be very contracted in area, inclosing an anchorage shallow and rocky. It has no just claim to the location of a *general* harbor of refuge.

Coming south from Crescent City, the next roadstead is that known as Trinidad Bay. As Trinidad appears on the chart, its geographical location as referred to the distance separating San Francisco Bay and the Straits of Fuca, it seems too far south, but referred to the magnitude of the coasting trade, as exhibited graphically upon the accompanying tracing, to which I again beg to call your attention, it will be found beyond comparison with any of the other locations under discussion the most adaptable to the use and objects of a harbor of refuge. It is immediately north of one of the most popular centers of industry and trade on the coast, that of Humboldt Bay.

The statistics upon which the accompanying graphical sketch are based show that 60 per cent. of the whole number of vessels trading north of San Francisco confine their trips to ports south of Trinidad, and consequently during southerly gales this 60 per cent. of the total number would be in the best possible position to avail itself of a harbor of refuge at Trinidad. In addition to this 60 per cent. which we find never sails north of Trinidad, we have the complementary 40 per cent. passing up and down the coast in regular trips, and as Trinidad is one-third of the distance north from San Francisco Bay to the straits—throwing aside the advantage of Columbia River and Coos Bay in favor of San Francisco section—we may credit one-third of the sea time of this complementary 40 per cent. to an area south of Trinidad, making a total of 73 per cent. of the number of the coasting fleet which on any given day during a winter gale would be able to make a lee behind a breakwater at Trinidad as compared with the remaining 27 per cent. too far north to make it available. But when we consider this 27 per cent. in numbers consists of large vessels which habitually go off shore and are better manned and equipped and prepared to weather out heavy gales at sea, there would appear to be no present apparent necessity for seeking a location for the proposed harbor of refuge even a single mile to the northward of Trinidad, unless it could be shown that there was some relative importance in the trade to Crescent City and Port Orford; but in fact this is so inconsiderable as to be not worth considering.

Nautically and commercially considered, Trinidad Bay is in location the most eligible situated of any of the half-harbors on the Pacific coast for the requirements of a general harbor of refuge, and if it were available to-day it would certainly be of the greatest use to the *greatest present number* of vessels in the coast fleet, and for reasons I have already suggested, if useful to-day, its usefulness in the future cannot be impaired by future changes, for, whatever these may be, they *must tend toward general development of volume in every locality, though special branches of trade may cease—though relative rates of progress may change and the relative importance of minor localities may be different from the present.*

Briefly to recapitulate the conclusions at which I have arrived:

As compared with Cape Gregory, Trinidad would be more commodious, would be much nearer to the bulk of the coasting commerce during southerly gales, equally easy of general approach, and much more readily entered with southerly winds and departed from with northwest winds. An equal expenditure would inclose more protected area at Trinidad than at Gregory.

As compared with Port Orford, Trinidad is less commodious; the skeleton harbor at Orford is on a larger scale. As to proximity and every approach to the bulk of the coasting commerce, Trinidad is largely superior to Port Orford. Trinidad has no outlying dangers. Orford has dangerous reefs on the north and south. An equal expenditure at Trinidad would inclose a larger protected area than at Orford.

As compared with Crescent City, Trinidad is much more commodious; it is nearer, and would be more accessible to the bulk of the coasting commerce during southerly gales; it is more easy of general approach, and would be entered with less risk at all times. An equal expenditure at Trinidad would inclose more protected area than at Crescent City. The general facilities for constructing a large harbor of refuge at Trinidad I believe to be greater than at any other of the localities named.

I have the honor, colonel, through you, to submit to the Board of Engineers my general conclusions in favor of Trinidad Bay as being the most suitable location for a harbor of refuge on the Pacific coast south of the Straits of Fuca. I have endeavored to avoid the discussion of special local details in which I could not have added to the information of the Board, and have confined myself to a general argument and comparison of the different localities proposed for a harbor of refuge.

I inclose herewith the tracing before referred to, based upon statistical data, graphically condensed into co-ordinates of departure and destination, showing the routes of coasting vessels and the comparative volume of trade in different localities upon the Pacific coast north of San Francisco.

I have the honor to be, very respectfully,

AUG. F. RODGERS,  
Assistant, United States Coast and Geodetic Survey.

Lieut. Col. C. S. STEWART,  
United States Engineers,  
President Board of Engineers Pacific Coast.



## LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,  
UNITED STATES ARMY,  
*Washington, D. C., February 24, 1881.*

SIR : In answer to the reference to this office of Senate resolution of the 19th instant, directing the transmission to the Senate, "for its information, a copy of the report of the Board of Engineers lately engaged in examining the several points on the Pacific coast, for the purpose of locating a harbor of refuge, and especially that relating to Port Orford, Oreg.," I have the honor to submit herewith a copy of a report to this office of January 15, 1881, from the Board of Engineers for the Pacific Coast, being a reconsideration of its previous reports upon the same subject.

The river and harbor act of March 3, 1879, appropriates \$150,000 to be expended by the Secretary of War in the commencement of the construction of a breakwater and harbor of refuge at such point on the Pacific Ocean between the Straits of Fuca and San Francisco, Cal., as may, in the opinion of a majority of the Board of United States Engineers for the Pacific Coast, be most suitable, the interests of commerce, local and general, being considered.

To comply with a resolution of the Senate of May 5, 1880, a majority and minority report of the Board of Engineers, dated March 6, 1880, was transmitted to the Senate May 8, 1880, and printed as Senate Ex. Doc. No. 188, Forty-sixth Congress, second session; and on May 24 there was also transmitted to Congress, as an appendix to the above, a letter from Assistant George Davidson, United States Coast and Geodetic Survey, in reply to a request from the Board asking the results of his observations and experience on the coast. As the selection of a site had been made by the Board before the receipt of this communication, it formed no part of the proceedings previously had. This letter was printed as part 2 of the above Congressional document. Subsequently, on June 3, another communication was received upon the same subject, also at the request of the Board, from Assistant A. F. Rodgers, of the United States Coast and Geodetic Survey. The Board also invited by public notice in the journals of the coast, all persons who so desired to submit their views, either verbally or by letter.

As some of these communications were not received by the Board in time for consideration before its report on the location of the harbor of refuge was made, and in view of the magnitude of the work, the importance of the fullest discussion of the subject, and of the diversity of opinion which appeared to exist, in some instances at variance with the views of the majority of the Board, with your sanction instructions were given to the Board to reconsider the whole subject. The report herewith submitted is made in compliance with these instructions.

It will be seen that this report is not a unanimous one; that the majority of the Board adheres to its former selection of Port Orford as the most suitable point, and reports that having studied and carefully examined the papers before it, and reconsidered the whole subject, it sees no reason for changing the views expressed in its report of March 6, 1880.

As will also be seen, the dissenting member adheres to his previously expressed opinion that Trinidad presents greater advantages than any other point, and reserves the right to present a full expression of that opinion at a later time.

It may be well to call attention to the estimate of the Board as involving, in all probability, an ultimate expenditure of about \$8,000,000 for the complete establishment of the harbor in question.

There is also submitted herewith the above-mentioned communication from Assistant A. F. Rodgers, United States Coast and Geodetic Survey.

The resolution of the Senate of February 19, 1881, is herewith returned.

Very respectfully, your obedient servant,

H. G. WRIGHT,  
*Chief of Engineers,  
Brig. and Bvt. Maj. Gen.*

Hon. ALEXANDER RAMSEY,  
*Secretary of War.*

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SUPPLEMENTARY REPORT OF THE BOARD OF ENGINEERS FOR THE  
PACIFIC COAST.

SAN FRANCISCO, CAL.,  
January 15, 1881.

SIR: In accordance with your instructions of July 20, 1880, the Board of Engineers for the Pacific Coast has reconsidered the subject of a site for a harbor of refuge on the Pacific Ocean between San Francisco and the Straits of Fuca, having before it, in addition to the data heretofore considered, the minority report and the communications on the subject of Assistants George Davidson and A. F. Rodgers, of the United States Coast and Geodetic Survey.

The general physical features of the North Pacific coast embraced within the limits above referred to, its meteorology, the character and course of traffic, and the disasters which have occurred are discussed in the various reports and papers as to their bearing on the proper location of a site for the harbor.

As a result of the discussion, all points except Port Orford and Trinidad have been rejected.

The majority prefers the former, the others the latter. The choice lying between these two roadsteads, other things being equal, the one nearest midway between the extreme harbors, San Francisco and the Straits of Fuca, should be selected.

Port Orford divides this unharbored stretch of coast into two nearly equal portions of 350 miles. Trinidad divides it into sections of 450 and 250 miles, the northern and most stormy portion, and therefore the one most in need of a harbor, being the longer.

Cape Blanco, 6 or 7 miles to the northwest of Orford, is the most western point of the coast south of the vicinity of the Straits of Fuca. Sailing vessels, when winds permit in winter, bound to ports north or south, and steamers always pass close to the cape and change their course at this point. This fact brings them near Port Orford, while they leave Trinidad at a distance when passing, it being in a bight on one side of their usual route.

It having been shown before the Board that shelter is chiefly needed from southern storms, and that these are comparatively not much to be dreaded below Cape Mendocino, but increase in violence from that point as you proceed northward, it is clear Trinidad, but 45 miles north of that cape and just within the southern or windward limit of the storm region, is altogether too far south, and cannot compare at all in position,

as the site for a general harbor of refuge from these winter storms, with Port Orford, 115 miles farther to the north and near the middle of the storm belt.

Trinidad, however, it is urged, should be selected because the greatest number of vessels is engaged in the local coast trade south of Cape Mendocino, and between it and San Francisco, and because these are small and not fitted to encounter storms at sea so well as larger vessels, and therefore this local traffic would be most benefited by placing the harbor of refuge at that port.

The law states the point to be selected should be that which, in the judgment of the majority of the Board, is most suitable, "the interests of commerce, local and general, being considered."

This forbids a selection based mainly on the grounds urged. The point is not to be chosen chiefly for the benefit of the local coast trade of part of California, but the interests of general commerce must also be considered. If there be not now any such considerable interests to be subserved thereby, it is assumed that there will be in the future, and that the Board must, to the best of its ability, so judge of what these may be hereafter as to locate now the harbor so as to satisfy these interests then.

The selection is not to be made for the present only, but for all time.

The dangers of the local coast traffic are known and the vessels are modeled and built to meet them. They average from 80 to 100 tons each. Many of them trade to the northern ports and can in winter storms, if there is to be but one harbor of refuge, make for Port Orford as well as for Trinidad. The former, while available for them, would be so, in addition, for all to the northward of the latter and between the two, which, under the circumstances, could not reach Trinidad to windward. The number of vessels engaged in commerce does not show the amount of the traffic. This is measured by the tonnage employed. One of the large vessels in the trade north of Trinidad may equal in tonnage 20 of the small ones coasting to the southward of that port, and may cost more than 50 or 60 of them. The consequences following the loss of one of the larger may, therefore, in money value and lives, equal those attendant on the loss of many of the smaller. The tonnage concerned must, then, be taken into consideration.

The following table, compiled from the records of the Merchants' Exchange in this city, gives the tonnage to and from San Francisco and ports north for the years shown:

To and from San Francisco and—	Tonnage.			Percentage of tonnage.		
	1870.	1875.	1879.	1870.	1875.	1879.
Trinidad and ports south of it.....	297, 184	373, 427	335, 189	32	26	21
Ports north of Trinidad .....	623, 115	1, 066, 064	1, 237, 523	68	74	79
Totals .....	920, 279	1, 439, 491	1, 572, 712	100	100	100

From this it is seen the tonnage to and from ports north of Trinidad is increasing steadily and more rapidly than it is to that port and those south of it.

At present nearly four-fifths of all this Pacific commerce goes to the north of that harbor, and this portion, when during winter storms to the north or leeward of Trinidad, can derive no benefit from a harbor of

refuge there. Whereas if it be placed at Port Orford all this commerce for an additional 100 miles in the stormiest region would or might be benefited. The interests of general commerce, then, would lead to the selection of this point.

If we consider the disasters that have occurred on the North Pacific coast, there is little to aid in choosing between the two locations, as is shown in Chapter V of majority report, March 6, 1880.

Owing to the fact that the winds blow essentially up and down the coast close in to the land, and that there are no very deep bights, a vessel in good condition is rarely, if ever, driven ashore by *stress of weather*. When she is more or less disabled, however, she cannot escape so readily. As disasters are more likely to happen in a very stormy region than in one less so, a harbor at Port Orford would then probably be of more benefit to vessels disabled by storms in winter than would one at Trinidad.

A wreck chart has been drawn giving the actual or approximate localities of disasters that have happened to vessels in the North Pacific during the eighteen years ending with 1878. This chart shows that the majority of wrecks between San Francisco and the Strait of Fuca has occurred south of Trinidad in the vicinity of Mendocino City and between it and San Francisco. Mendocino City is midway between the latter and Trinidad. The number of wrecks from Mendocino City north has gradually diminished with the increase of latitude. This is consequently assumed by the minority to be a strong argument against selecting a point for the harbor of refuge north of Trinidad. Whether the greater number of wrecks to the south of Trinidad should have any influence on the selection of that port rather than one farther north as the site, depends upon showing that the circumstances under which these occurred were such that these disasters could or would have been prevented by a secure harbor there. This has not been and cannot be proved.

The chart referred to does not give any of the circumstances attending the losses marked on it; therefore from it one cannot determine whether a harbor of refuge at any point named to the north of Cape Mendocino could have prevented any or many of these wrecks. It does not in this view aid in the solution of the problem. As has been already stated, a vessel under sail is scarcely ever driven ashore on this coast by *stress of weather*. The great number of wrecks south of Mendocino City is not, then, due to that cause. It is found for the five years from 1875 to 1879, inclusive, referred to in table of wrecks, Appendix I, majority report, March 6, 1880, that 52 per cent. of the tonnage, 57 per cent. of the money value, and 70 per cent. of the lives lost could not have been prevented by a harbor of refuge, being due to foggy weather, to severe collisions, carelessness, errors of judgment, misreckoning, and bad management. Many of the wrecks south of Mendocino City were owing to these causes, and happened to vessels under sail when approaching the entrance to San Francisco Bay, and therefore far away from any proposed refuge.

The wreck chart shows that 33 per cent. of the number of losses, without reference to their magnitude, during 18 years were between San Francisco and Point Reyes, about 30 miles to the west and north of this city, and, so to speak, in the jaws of its harbor; that 28 per cent. took place between Point Reyes and Crescent City, north of Trinidad; the remaining 39 per cent. occurred farther up the coast. The 33 per cent. lost off San Francisco have no bearing on the location of the harbor of refuge. But the table mentioned gives most of the losses below Mendocino City as happening to vessels at anchorages. The reason is plain.



Along this part of the coast are many chutes and places for shipping lumber and produce. All of these are more or less exposed and open to sea and wind. Vessels at them are liable to be caught at almost any moment, and moorings exceptionally strong are therefore prepared to hold them. Small coasters that can be easily handled and hauled off quickly to these are employed, since larger vessels would be too unwieldy and the moorings could not hold them against sea and wind. It is said that at these anchorages the swell precedes the storm by from 12 to 48 hours. At the beginning of the gale the small coasters haul up to the moorings, the crews go ashore, and if everything holds the vessel rides out the storm; if not, she is stranded and more or less damaged.

It is believed, from the circumstances of the case, very few, if any, vessels can get away from these little roadsteads at the beginning of a southeast storm. For then there is but little wind, or it is calm inshore, under the lee of the land. The swell has already set in, and the vessel, being very close to the landing, would if she cast off her moorings, be hove on the rocks before getting under any headway. When the wind becomes strong the sea is too heavy to attempt to contend with under short sail.

The following table (compiled from Table 1, Appendix I, majority report, 1880) of the circumstances of the stranding, &c., of 43 schooners, all that were wrecked during nearly five years, south of Cape Mendocino, confirms these views:

*Schooners wrecked and more or less damaged between San Francisco and Cape Mendocino during 1875-'76-'77-'78, and ten and one-half months of 1879.*

Remarks.	No.	Tonnage.	Damages.	Lives lost.
At anchorages during southerly gales, with heavy seas.....	12	955.55	\$57,450	1
At anchorages during northwesterly gales, with heavy seas...	3	239.39	13,025	.....
At anchorages during calms or light winds, with heavy seas...	17	1,122.51	99,781	4
At points of coast during light winds, fogs, &c., with heavy seas.....	11	910.02	52,720	4
Total .....	43	3,227.47	222,976	9

The loss of life was on four vessels.

From this it is seen that 28 of these disasters happened where, from want of wind, no harbor of refuge could have been reached. In three more the wind was ahead for any port to the northward. It is doubtful whether many, if any, of the 12 which were driven ashore during southerly gales from their anchorages could have escaped if the heavy swell, as is usually the case, preceded the storm. Admitting, however, that all these could have made an offing and run before the wind to Port Orford or Trinidad, the saving effected by a harbor of refuge at either place would have averaged for each year considered  $2\frac{1}{2}$  schooners, a little less than \$12,000, and about one-fifth of a life.

From the physical facts of the case and from these statistics, it seems clear that the great number of wrecks south of Mendocino City have occurred under circumstances such that the vessels could not have reached a harbor of refuge, and cannot, therefore, be used as an argument in favor of Trinidad rather than Port Orford as the proposed site.

So long as there is trade to these *outside ports*, wrecks will occur unless breakwaters are constructed at each or nearly all.

Mendocino City is about 125 miles from San Francisco Bay and midway between it and Trinidad. The number of vessels and the tonnage

engaged during 1879 in the local coast traffic between San Francisco and the equal sections north and south of this half-way point are given below:

Traffic for the year 1879 between San Francisco and—	No. of vessels.	Tons.	Percent. of vessels.	Percent. of tons.
Mendocino and ports south of it .....	2, 020	171, 377	71	51
Trinidad and ports north of Mendocino City .....	837	163, 812	29	49
Total .....	2, 857	335, 189	100	100

Hence it appears that 71 per cent. of the vessels and 51 per cent. of the tonnage referred to, go to ports within 125 miles of San Francisco. The large fleet of local coasters talked of trades mainly in this section. It may be doubted whether any of the masters of these would leave an anchorage in a southeaster and run from 125 to 250 miles to leeward to take refuge at Trinidad, having to pass through the heavy seas to be met with off Cape Mendocino, when instead the crew, after making their craft fast to the moorings, could go ashore and stay there. It is then fair to infer from the character and amount of the traffic south of Mendocino City, just considered, that a harbor of refuge placed at Trinidad would be of little service to the large fleet of small coasters, excepting to those vessels bound to that port or to Humboldt Bay, just south of it. In other words, the resulting benefit to commerce from the selection of this site would be wholly of a local character, not even extending to many of the ports south of Cape Mendocino. The fact that not a mill-owner or master mariner from this section below Mendocino City has ever appeared before the Board and said anything in favor of a harbor of refuge at Trinidad sustains this view. In this connection we quote (Appendix 1)\* from the answer of a mill-owner south of Mendocino City to an inquiry made upon this point:

A harbor of refuge built north of Cape Mendocino would not be used by this fleet to any considerable extent.

In the majority report it was believed to be true that the traffic of the narrow belt which finds its outlet by the numerous fleet trading to ports south of Trinidad—

Has nearly if not quite reached its maximum. Its principal cargo is redwood timber, and the next generation will probably witness a decline in this business. It will probably be a continually lessening fraction of Pacific commerce.

An advocate for Trinidad, the minority, controverts this assertion. After referring to the growth of the coast commerce between San Francisco and Trinidad, and illustrating it by contrasting the exports from Eureka in 1875 and 1879, and by the number of steamers and sailing vessels arriving at and departing from that port, in that year, compared with those entering and leaving the Columbia River, he remarks:

The foregoing facts disprove the assertion made in the majority report, that this portion of the coast commerce will probably be a constantly lessening fraction of Pacific commerce.

The table of tonnage of this commerce for the years 1870-'75-'79, already given, shows conclusively that the trade of the coast between Trinidad and San Francisco for those years has been a lessening frac-

\* Omitted. The appendixes to this report may be found printed in Senate Ex. Doc. 59, Forty-sixth Congress, third session.

tion of Pacific commerce, having decreased from 32 per cent. to 21 per cent. during that interval.

The traffic to and from San Francisco and Humboldt Bay, including Eureka, is here given:

TONNAGE TO AND FROM SAN FRANCISCO AND HUMBOLDT BAY.

	Tons.
1875 .....	139,615
1879 .....	129,111

That is, the amount in 1879 is but 92 per cent. of that for 1875, a falling off of 8 per cent. To Trinidad and the ports south there is a decline of 10 per cent. between the same years, while the traffic for ports north of Trinidad has increased 16 per cent., and the whole North Pacific commerce has gained 9 per cent. These statistics show that the assertion of the majority has not been disproven, but, on the contrary, was correct.

As the commerce of the north is developing more rapidly than that of the narrow belt of the California coast under consideration possibly can, this disparity must continue to increase.

In support of this opinion it may be stated that recently arrangements have been made for the construction of a large steamer of 3,100 tons, and the purchase of two more, the three aggregating 9,000 tons, to be employed in the coal and coast trade. Two other large ones have been chartered abroad to run as colliers to Puget Sound. In a few months, therefore, the steam tonnage of the North Pacific will be increased by at least 12,000 tons. One of these steamers, from its more rapid trips and greater carrying capacity, will, in the same time, do the work of three or four of the ordinary sailing vessels. The tendency now is, here, as well as it has been elsewhere, such that in all probability the greater part of the foreign and domestic trade, in most branches, will ultimately be carried in steamers. Messrs. Goodall, Perkins & Co. (Appendix E, minority report) in reply to the question by him—

Do you think it probable that sailing vessels will in the future be replaced by steam vessels in the foreign or domestic commerce of this coast?

say:

Excepting in the transportation of lumber and in business seeking an outlet by Cape Horn, we think that steamers will more than likely supplant sailing vessels, and that too, before many years.

They have for a long time been running steamers to different ports on this coast, and know whereof they speak.

The logic of facts, then, seems to favor the opinions expressed to that effect by the majority in Chapter VI of its report of March last, and dissented from by the minority.

In this connection the following remarks of the minority may be quoted:

The evidence before the Board, and particularly that presented in this minority report, proves conclusively that a harbor of refuge at Port Orford would *not* be of any benefit to, or be used by, the large and substantially equipped steamers and sailing vessels that are engaged in that northern trade.

The evidence before the Board was not against Port Orford. The master mariners believed a harbor of refuge *anywhere* on the coast would be of little or no use to these vessels, or, indeed, to any other, *unless when disabled*, or in its vicinity at the beginning of a southerly gale. If they would not avail themselves of one located at Port Orford in the stormiest region, for still stronger reasons they would never use one at Trinidad, in a less stormy latitude, much farther on one side from their usual route and in a bight subject to bogs and thick weather.

The evidence presented by the minority on this point consists almost wholly of *opinions* of persons who think Trinidad to be a preferable site, but whose opinions do not prove conclusively that a harbor of refuge at Port Orford would never be of benefit to or be used by the classes of vessels referred to. Steamers, as well as other vessels, are liable to disasters, and then will use, if practicable, any port available.

Port Orford Reef has been admitted by the majority to be a serious objection to the selection of this site. It does not, however, obstruct the approach during the southerly gales, from which shelter is sought. It is then to leeward, the southern end being some 5 miles to northward of west from the headland of Port Orford.

The reef lies parallel to the coast and 3 miles off. Between it and the coast is a quite straight channel of 10 fathoms,  $1\frac{1}{2}$  miles wide, which is often used by steamers. One of the worst rocks is Fox Rock, which is to the southwestward of the main body of the reef, nearly  $1\frac{1}{2}$  miles off. It is a small rock, just awash; with this exception, the west side of the reef shows no danger. The reef itself is, in clear weather, easily recognized by the high rocky islets. Steamers have sometimes passed through the reef itself. (Board Report, March, 1880.)

The minority makes the supposition that a sailing vessel in thick weather and in a heavy southwest gale is desirous of making a harbor of refuge supposed to be placed at Port Orford. She falls a little to leeward. He asserts it would then be impracticable for her to make the steamer channel, because a vessel under short sail and "hailed up close to the wind, as she would have to be, would make almost as much leeway as headway, and the consequence would be she would soon be driven ashore."

The masters of vessels who appeared before the Board stated positively that during a heavy southerly gale accompanied by thick weather, no seaman, unless absolutely sure of his position, or in the last extremity, would ever attempt to run for a harbor of refuge placed at *any point whatever of the coast*. The risk would be too great. Admit, however, the case to be as supposed.

These same mariners also affirm uniformly that whatever may be the direction of the wind *outside*, it follows *inshore* more or less closely the line of the coast. The general trend of this at Port Orford is nearly north-northwest and south-southeast. Therefore, with a heavy southwest wind on the open sea it should blow *inshore* parallel to the coast, or from south-southeast. This direction, under these circumstances, it is stated by an old mariner living at this port, to have invariably. (See Appendix 2.\*)

Assistant George Davidson, United States Coast and Geodetic Survey, in his paper confirms this in these words:

My personal recollection of the direction of the wind here in winter storms is that it comes from the south.

A vessel, then, in the position assumed by the minority, could, with a south-southeast wind, head west-southwest or southwest by west some two or three points to windward of the southernmost rock of the reef; or, since the direction of the steamer channel is about northwest from the harbor, the wind even if south would be free or on her quarter and fair for making that channel. In passing through it the masses of kelp on the reef to seaward would tend to keep down the sea there.

A brig, in 1852, it is said (Appendix C, majority report), at night, in a southwest gale, passed, without damage, through the reef itself. Hence, at the worst, it does not follow necessarily that a vessel missing a harbor of refuge placed here would be driven ashore, as is maintained

\* Omitted.



by the minority. The chances would be greatly in favor of her escape even if in a somewhat disabled condition.

The minority, in objecting to the position of the entrance to the harbor of refuge at Port Orford as projected by the majority of the Board, refers to the evidence given by mariners, and to the appendixes to his report, to show that it is indispensable to have the entrance opening to the south.

What was stated by mariners before the Board was duly weighed by it in making its project. Upon examining the appendixes to the minority report, it is found one naval officer says the entrance should open to the southward and eastward, and be neither parallel nor at right angles to the crest of the waves; another, that it should make an angle of from  $30^{\circ}$  to  $45^{\circ}$  with the crest of the heaviest waves.

In the sense in which the word has been used before the Board and by these gentlemen, the projected entrance is to the south or southward and eastward. At all events, it fulfills the essential condition that it can be entered with a free wind by a vessel, whether in distress or not, under any circumstances in which she could enter a harbor of refuge at any other point on the coast. As has been already shown the wind here in southerly gales blows from the south-southeast or thereabouts. The line of breakwater runs a little south of east. A vessel to windward of the port, under any control, would have the wind free, could lay her course for the entrance, and as soon as the eastern end of the work was passed could, in comparatively smooth water, alter her course with the wind on her quarter or nearly aft, and take any berth wished (Appendix 2). It would not be necessary to haul close to the wind and get into the trough of the sea, or drift into the breakers to leeward, as has been maintained by the minority.

An argument used by him for changing the direction of the projected line of the breakwater just referred to, so as to throw it into excessively deep water and thereby greatly increase its cost, is based, in part, upon the assertion that it is a "fact that at Port Orford Harbor the sea frequently breaks in 10 fathoms and often in 14 fathoms."

It was nowhere asserted in evidence before the Board that the sea ever breaks in 10 fathoms at this harbor.

H. B. Tichenor, after an absence of some twenty-four years from Port Orford, in reply to a query by the minority, writes from recollection:

I am quite positive I have seen it break in 14 fathoms.

Now, after examination of a chart of the roadstead, still trusting to memory, he writes:

I find there is from 10 to 11 fathoms abreast of the cove, and therefore I may be mistaken in saying it broke in 14 fathoms.

On the other hand, a resident there for twenty-eight years, a mariner, says:

I have never seen a sea break in over 8 fathoms. (Appendix 2.)

Assistant George Davidson, United States Coast and Geodetic Survey, who is a close observer, in writing of the coast generally, with which he has been well acquainted for years, remarks:

My opinion is, I have seen it breaking in from 7 to  $7\frac{1}{2}$  fathoms water.

He has a vivid remembrance of the force of the sea at Port Orford during the prolonged gales of December, 1851. Had there been, while he was there, during these winter storms, any breakers in such abnormal depths as 10 and 14 fathoms, he could not fail to notice them, and would not now limit the depth in which he has observed them to from 7 to  $7\frac{1}{2}$  fathoms.

It is therefore *not proven to be a fact* that seas break at that harbor "frequently" in 10 and "*often*" in 14 fathoms. The argument based on such assumption falls to the ground.

It may be well to state here that the general alignment and position of the breakwater was made at Port Orford with the harbor and its chart before the Board, after all the information it could obtain was in its possession, and with an experienced seaman, familiar with the locality and the direction of the winds and seas, present to aid it in determining the proper location of the work. The minority of the Board assented to the location and cross-section of this breakwater until the adoption of the majority report.

A possible modification in position that may finally be given to this line will be found farther on in this report.

#### THE ESTIMATES OF THE MINORITY REPORT.

We now proceed to examine the estimates made in the minority report. They are peculiar in that they differ very widely from any heretofore made by the Board, including the minority, for either Trinidad or for Port Orford. They have the further peculiarity that, while the minority estimate for Trinidad is deducible from its previous estimate by dividing the latter by 3, the inverse process of multiplication by 3 must be applied to its previous estimate for Port Orford in order to express the existing views of the minority in regard to this point.

The previous estimates here referred to will be found in the report of the Board of February 14, 1877, published in the report of the Chief of Engineers for that year.

In order to be clear we state that the majority of the Board in 1877, including the author of the minority report, agreed upon a project for Trinidad Harbor, to cost \$7,964,500, which should cover 510 acres of anchorage outside of the 3-fathom curve.

The minority now proposes to cover  $1\frac{1}{4}$  square miles, at a cost of \$2,587,530, or, as an alternative proposition, 320 acres, at a cost of little over \$1,000,000. The cost per acre covered is thus reduced nearly five fold, being \$15,600 per acre in 1877 and \$3,250 in 1880.

This difference is certainly on its face extraordinary. Something of the same kind of change may be observed in the minority report in reference to Port Orford, with this difference, that while the minority agreed with us in 1877 for a project for Port Orford, to cost \$10,507,343, it is now maintained that something like \$30,000,000 will be required for this point.

It becomes our duty to trace out the steps of the argument which the minority relies upon to sustain his new positions. This we are enabled to do in the case of Trinidad with a good deal of exactness, for the reason that the premises are clearly stated and reasoned upon, but when we come to examine the basis for the conclusion for Port Orford the steps are not so clearly stated; therefore, the cost assigned to the work there is perhaps more of a conjecture than an estimate.

The reduction in the Trinidad estimate will be found on analysis to be based mainly upon a statement that the winter swell approaches that port not from the southwest, as has been generally supposed, but from the magnetic west, a direction differing  $45^{\circ}$ . If there is no swell from the southwest a breakwater need not have an easterly branch, but a construction from Trinidad Head to Pilot Rock would alone suffice to give a well-protected harbor.

The statement of the case is thus made in the minority report:

It has been stated in evidence before the Board that at Trinidad the heavy swell which is so disastrous to vessels at anchor when subjected to it, comes from a direction magnetic west. The letters of S. Bainfield and F. P. and J. A. Hooper, herewith inclosed, marked A and B, are two in connection with many others sent on with the majority report to confirm this fact. This is important, for it shows that if a breakwater were built from Trinidad Head to Pilot Rock, and a line were drawn magnetic west from the southern extremity of the rock, the area included by this line, the line of the breakwater, and the 3-fathom curve will be  $1\frac{1}{2}$  square miles.

The capacity of the harbor thus obtained is illustrated in the minority report by a picture of forty first-class ships of war, each swinging within a circle of 800 feet in diameter. In the closing paragraph of the report the statement is made that 320 acres will be covered by a breakwater one-quarter of a mile long, at a cost of little over \$1,000,000.

The statement that the sea comes only from the magnetic west, and not from the southwest, is the corner-stone of the minority report. Upon this the whole fabric rests. We hope to show that this position is not only unsupported by sufficient evidence, but that it is in opposition to evidence and to all the reasonable probabilities of the case, and in conflict with the history of Trinidad.

We remark a point which is not noticed in the minority report, which, if noticed and duly considered, would, very early in the inquiry, have conveyed to the mind of the author a feeling of distrust in the soundness of his premise. The area of the protected harbor is deduced by drawing a line in the direction of the swell assumed as magnetic west, through the southern edge of Pilot Rock. This area to the 3-fathom curve is stated to be  $1\frac{1}{2}$  square miles. We remark incidentally, without making any particular point of the difference, that we find this area to be 720 acres—a reduction of 80 acres.

Again, having a breakwater one-quarter of a mile long, beginning at Trinidad Head, the minority draws a parallel line magnetic west, through its extremity, and covers, according to his estimate, 320 acres—again to the 3-fathom curve.

Now, if he had drawn a third line magnetic west tangent to the southern end of Trinidad Head, he would have found 230 acres to the 3-fathom curve protected in exactly the same manner without any breakwater at all; that is, there is already a harbor of refuge at Trinidad. It is a matter of common knowledge that this is not the case. The evidence in its favor, however, is exactly the same as that which is relied upon to prove that a breakwater 2,680 feet in length will cover 809 acres, and that one half this length will cover 320 acres.

There is another point which, if considered, was calculated to arrest the attention and to produce a feeling of uneasiness as to the soundness of this fundamental premise. This point lies in the singularity of the phenomenon of a storm, beginning in the southeast and blowing throughout its duration of one or several days from this quarter, veering in succession over the open sea through south, south-southwest, to its maximum strength in the southwest, without sending into a roadstead opening to the south waves having any southing in direction. Otherwise stated, the phenomenon is that the southerly winds just referred to drive waves into the harbor from the magnetic west, which is  $18^\circ$  north of true west, the variation of the compass being  $18^\circ$  east at Trinidad. This is the direction which Assistant Bradford (Appendix A, majority report) assigns to the waves at Trinidad, produced by the northwest winds.

We now examine the evidence cited by the minority in support of this proposition.

It has been stated in the quotation already made as to be looked for in the letters of S. Bainfield and of F. P. and J. A. Hooper, "in connection with many others sent on with the majority report."

We have been able to find but two letters accompanying the majority report which bear upon this point. These are the letters of Assistant G. Bradford, Coast and Geodetic Survey, and F. P. and J. A. Hooper, of June 11, 1879, both to be referred to hereafter. Inasmuch as both these letters describe the winter sea as southwesterly, it is to be presumed that they are not those referred to as the whole or a part of the "many others sent on with the majority report" confirming the proposition of a sea magnetic west.

We find, however, among the witnesses who appeared before the Board two other parties who expressed opinions on this subject. They are J. C. Glidden and Captain Lass. We have examined these references with care, as recorded in the stenographer's report of testimony taken before the Board. Captain Glidden is reported in the abstract of testimony as saying that the swell at Trinidad comes from "nearly west or a little south of it." In the report of testimony he is asked the following question and gives the following answer:

Question. Which direction do you say it is; west or south of west?

Answer. Well, it is very nearly west; it varies very little from that—true west.

It will be remembered that true west is  $180^\circ$  south of magnetic west.

Captain Lass says that the swell comes in from nearly due west.

Captain Bainfield (Bonnifield in the Board record) states in his letter that the "sea comes in about due west." In his testimony before the Board, he says:

The next day after a southeaster the swell gets around to the westward and makes a heavy undertow.

F. P. & J. A. Hooper, mill-owners, having extensive interests at Trinidad, appear twice on the record in regard to this point. In presenting the claim of Trinidad, in a letter to the Board, dated June 11, 1879 (Appendix A, majority report), they say:

When the wind is in the southeast or southwest the sea always comes in from the southwest.

Qualified afterwards by saying west by south.

The minority makes no reference to this letter, but cites the letter of February 28, 1880, which states that the—

So-called southwest swells invariably come in between the Head and Pilot Rock due west, and at times a fraction north of west.

The two statements can perhaps be reconciled by the supposition that the swells enter the harbor between Pilot Rock and the shore from the southwest. It is not, however, our part to reconcile statements that appear to contradict each other.

This is the record. If it contains any testimony in favor of a swell from the magnetic west, it is in the statement of Captain Lass and in the letter of Captain Bainfield of February 28, the same date as the last letter of F. P. & J. A. Hooper, in whose employ he is as a master of a schooner. Neither of these states it distinctly, Captain Lass saying nearly due west, leaving us in doubt whether the true or magnetic west is meant. The term westerly, used by Captain Bainfield, is often used to mean a direction more nearly west than north or south; as, for in-



stance, Assistant Bradford says, "the southerly wind is from the southwest."

There was other evidence on the record coming from Assistant Bradford, of the Coast and Geodetic Survey, who made the survey of Trinidad in 1872, and who is an advocate of a harbor at this point, which seems not to have attracted the attention of the minority. This will be found in Appendix A, majority report, as follows:

The strong southerly wind is from the southwest, with a sea from nearly the same direction.

This statement is corroborated by Mr. Dickins, of the same service, who was with Mr. Bradford on the survey of Trinidad. This is not, however, on the record.

Assistant George Davidson, Coast and Geodetic Survey, in a recent note to a member of this Board, says:

We know that at Cape Mendocino the great winter swells come from the southwest, and I have laid fourteen days off Humboldt Bar in southeast weather with southwest swells; therefore I feel convinced that the winter swell at Trinidad comes from the southwest.

In a sketch he indicates the probable direction of the swell as true southwest, which is more than five points of the compass from magnetic west.

Captain Wheeler, who sailed to Trinidad for parts of three years, says in a letter hereto appended (Appendix 3\*):

That while seas come from the west during the winter, the heaviest come from the southwest.

Captain Fauntleroy gives a similar description of the sea in Appendix B, majority report.

Our last witness is one that will again appear in this paper in opposition to the opinions of the minority. This witness is the minority. His opinions on this subject will be found on page 1051, Report of Chief of Engineers, as follows:

Here it may be remarked that throughout the sea coast of California and Oregon, when the wind is strong from the south, southeast, or southwest, the waves always approach the shore from the southwest, and it is natural that this should be the case, for if we suppose waves to be generated by a southerly wind, having their crests on an east or west line, or even in a direction at right angles to the trend of the shore, the western ends of these waves will be in deeper water than the eastern ends, and, according to the laws of wave-motion, their western ends would travel faster, and thus the crests of such waves would gradually be brought to a northwest and southeast direction, the translation of such wave-motion being from southwest toward northeast.

Any breakwater, therefore, at any of the harbors now under consideration must be so located as to afford protection from the sea in that direction.

We have referred in confirmation of the generally held opinion of a southwest sea to the history of Trinidad as being that of a dangerous winter anchorage. We call attention without quoting to the record, p. 103, Official Coast Pilot, which notes a number of wrecks at this place in years gone by.

We are concerned to show that a heavy winter sea comes from the southwest. We are not concerned to deny that a winter sea sometimes comes from the westward. We think the opinion that a sea comes from the southwest has been fully sustained. If so, a breakwater from Trinidad Head to Pilot Rock, 2,680 feet in length, will not cover either the 800 acres of the minority report or the 720 acres, as we have measured it. The picture of forty first-class men-of-war peaceably swinging at anchor behind the line, each with its own circle of 800 feet in diameter,

\* Omitted.

is not capable of realization; nor will a breakwater one-quarter of a mile long cover 320 acres.

The line from Trinidad Head to Pilot Rock needs to be supplemented by another branch of equal or greater length easterly in direction, in order to give cover to an area very much less than 800 acres, or even than 720 acres. The cost of covering this lesser area must, then, be quite twice that of the line from Trinidad Head to Pilot Rock.

This brings us to inquire what area would be covered by this line alone. We remark that the closure of this line would shut off about one-third of the area of the avenues by which the southwest swell enters the roadstead. There would still remain an avenue of 1 mile of width, having more than 5 fathoms depth, by which the heavy sea could enter.

We regard it as very doubtful whether the anchorage over any considerable area, under this exposure, would be entirely safe. With the construction proposed by the minority, the reflection of the waves from the shore meeting the heavy direct inset would, in our judgment, make the anchorage very uncomfortable, if not unsafe.

The direction of the winter sea requires, as we have seen, that the minority estimate shall be doubled.

We have yet to trace the influence on these estimates of another assumption made by the minority.

The question of a suitable supply of stone for a work of this kind, has in every consideration of the problem been a matter of great concern. There must not only be a sufficient quantity of stone, but there must also be a sufficient supply of large stone. The cretaceous series of rocks, which are found in the shape of a metamorphic sandstone both at Trinidad and at Port Orford, are cut up by planes of division, and when quarried are apt to give an undue supply of small stone and a small proportion of sound large stone. The numerous excavations in these rocks about San Francisco afford ground for this opinion, which was unanimously shared by the Board in 1877.

The Board in its project submitted in that year provided for a mound of natural stone from the locality to rise to the level of low water. The part above low water was projected of granite, to be taken from quarries in the Sierra Nevada or at Monterey; so that the only supply of large, natural stones required from the site of the harbor was enough to form the slopes below low water.

The minority now proposes to make the whole slope to a height of 20 feet above low water of natural stones. The maximum exposure of the work lies on the portion above low water, so that not only the number, but also the sizes of the stones required by the minority work is largely in excess, perhaps several times, of that required by the Board in 1877.

We quote in a note the remarks of the Board on this point in 1877, for the purpose of contrasting the cautiously-expressed provision for a small supply of stone with the confidence with which the minority now provides for a much larger requirement.

#### NOTE.

[Board report of 1877.]

The rock on the coast is metamorphic sandstone, and would generally be broken into small pieces in quarrying. Nevertheless, judging from the solid masses of stone which erosion has left along the sea-shores of this coast, we think, in quarrying so large a mass as would be required for the construction of a breakwater, that many large stones of a compact nature could be obtained at almost any quarry that might be opened. We propose to build the base of any breakwater, up to the height of 15 feet below the level of low water, of small stone; that is to say, of such stone as any

quarry will furnish; and, while quarrying out this great mass, to lay away all large stones of 5, 10, or 20 tons for the construction of that portion of the breakwater from 15 feet up to low water.

Upon this foundation we propose to build a masonry wall, faced with granite, 25 feet wide and 20 feet high, including the foundation, protecting the seaward side by blocks of artificial stone (if natural stone cannot be obtained) of large size (20 to 30 tons each), and thoroughly paving the harbor side with large blocks of granite to receive without displacement the water that will be thrown over the wall in great storms.

[Extract from minority report, 1880.]

There is little doubt that a sufficient quantity of large pieces of rock, ranging from  $\frac{1}{2}$  to  $7\frac{1}{2}$  cubic yards, can be found for this purpose, while quarrying out the large quantity of stone required to build the breakwater.

Now, we do not mean to assert that the confidence of the minority may not possibly be justified in the future. We would, however, have been pleased to know the reasons which have so changed its opinion on this important point in the past three years.

We adhere to the views held by us in 1877, and maintain that the probabilities are largely against a sufficient supply of suitable natural stone. We also think that owing to the larger extent of cliffs at Port Orford, showing a steep front to the sea, that the chances of a sufficient supply there are much greater than at Trinidad. We have not, however, thought ourselves on that account to be justified in making an estimate on that basis unless, indeed, as stated at the close of our former report, the fore slope be taken as 1 on 12 to low water, this long slope permitting the use of smaller material than a steeper slope. The estimate of the Board is therefore based on a slope of one-third in large artificial blocks. The effect of this in the estimates is shown by the fact that while the quantity of artificial blocks is only 17 per cent. of the mass, the cost is 55 per cent.

We now maintain that if the minority estimates on natural stone, the quantity ought to be required to make a slope of 1 on 12, which is that at Holyhead. We are not called upon to follow out this calculation to see what increase it would entail on the estimates.

There is one other point of difference between our estimates and those of the minority. We place our natural stone at \$1.25 and \$5 per yard, according to sizes. The prices of the minority are placed at \$1 and \$4, a reduction of 20 per cent. We are not aware of any reason why stone cannot be obtained as cheaply at Port Orford as at Trinidad. The tables of cost, just following, present the subject of estimates in a way that will make the processes of estimating quite plain. If we assume the minority profile and prices for Port Orford, the cost would be 52 per cent. of our estimate. On the other hand, our profile and prices applied to the minority line at Trinidad more than double the cost. This comparison of cost seems to relieve us from the necessity of pointing out in detail the inadequacy of the construction proposed by the minority.

The use of piling for the support of railways for the transportation of quarried material for deposit in place will not prove more difficult here than at Trinidad, for the seas are known to break there between Pilot Rock and Trinidad Head in more than 8 fathoms of water. Captain Connor, when examined before the Board, described how the decks of his steamer once in leaving that harbor had been swept by breakers between these points. The breakwater projected by the minority for Trinidad is to connect the Head with Pilot Rock. The plan proposed is faulty in that no opening is left at the north end of the breakwater between it and the Head for the passage of the littoral current to prevent the retention of the material brought into the harbor, which would otherwise tend to destroy its availability.

*Alternative estimates for breakwater at Port Orford. Board's location.*

BOARD'S SECTION, PRICES, AND LOCATION.

Depth below mean low tide.	Length.	Twenty-five-ton stones.	Ten-ton stones.	Four-ton stones.	Rubble.	Total cost.
	<i>Feet.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	
9½ fathoms.....	300	19,134.00	10,000.00	22,333.33	101,917.00	.....
10¼ fathoms.....	1,275	81,319.50	42,500.00	94,916.66	417,650.00	.....
11¼ fathoms.....	975	62,185.50	32,500.00	72,583.32	446,234.75	.....
10½ fathoms.....	1,410	89,929.80	47,000.00	104,966.65	604,551.60	.....
		252,570.00 @ \$12	132,000.00 @ \$10	294,800.00 @ \$5	1,670,350.00 @ \$1 25	.....
		\$3,030,840 00	\$1,320,000 00	\$1,474,000 00	\$2,687,937 00	\$7,912,777

MINORITY'S SECTION AND PRICES, BOARD'S LOCATION.

Depth below mean low tide.	Length.	Large stone, 2 to 10 tons.	Small stone.	Total cost.
	<i>Feet.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	
9½ fathoms.....	300	38,822.0	130,761.1	.....
10¼ fathoms.....	1,275	164,993.5	643,851.4	.....
11¼ fathoms.....	975	126,174.9	544,600.7	.....
10½ fathoms.....	1,410	182,463.4	745,341.5	.....
		512,451 @ \$4	2,064,555 @ \$1	.....
		\$2,049,804	\$2,064,555	\$4,114,359

*Alternative estimates for breakwater at Trinidad. Minority's location.*

BOARD'S SECTION AND PRICES.

Depth below mean low tide.	Length.	Twenty-five-ton stones.	Ten-ton stones.	Four-ton stones.	Rubble.	Total cost.
	<i>Feet.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	
6 fathoms.....	100	6,373	3,333	7,444	13,137	.....
7½ fathoms.....	600	38,268	20,000	44,664	129,700	.....
8¼ fathoms.....	1,760	112,253	58,667	131,014	459,523	.....
8½ fathoms.....	220	14,032	7,333	16,377	64,236	.....
		170,931 @ \$12	89,333 @ \$10	199,499 @ \$5	666,596 @ \$1.25	.....
		\$2,051,172	\$893,333	\$997,495	\$833,245	\$4,775,245

MINORITY'S SECTION AND PRICES.

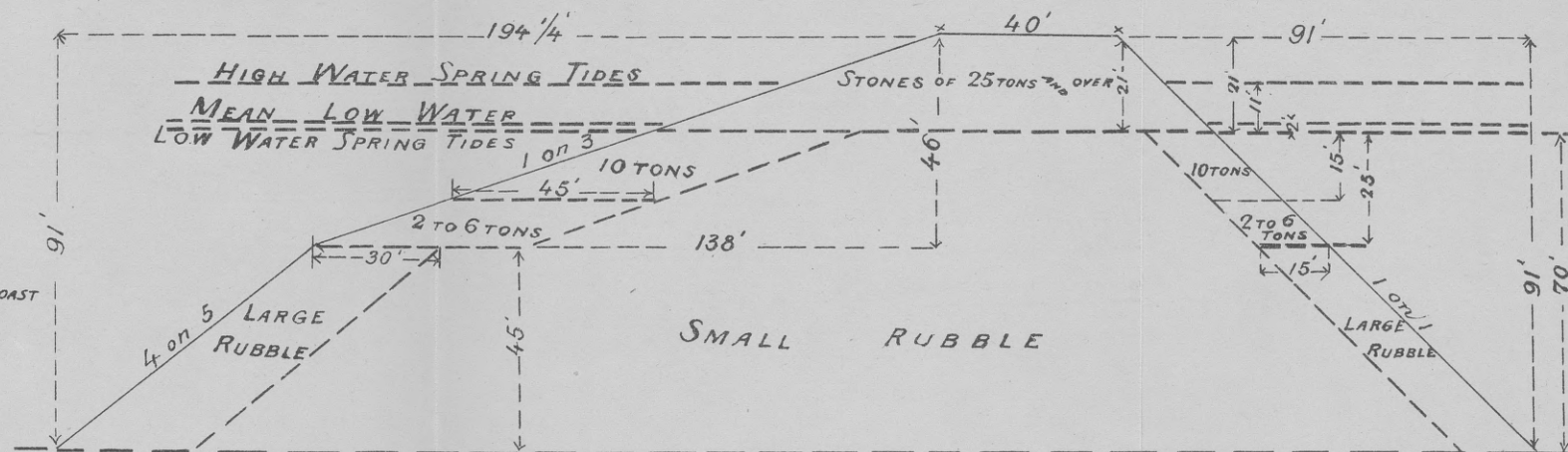
Depth below mean low tide.	Length.	Large stone, 2 to 10 tons.	Small stone.	Total cost.
	<i>Feet.</i>	<i>Cubic yards.</i>	<i>Cubic yards.</i>	
6 fathoms.....	100	12,940.8	12,498.1	.....
7½ fathoms.....	600	77,644.8	183,388.8	.....
8¼ fathoms.....	1,760	227,758.1	621,687.4	.....
8½ fathoms.....	220	28,469.8	84,873.1	.....
		346,813 @ \$4	911,447 @ \$1	.....
		\$1,387,252	\$911,447	\$2,298,699



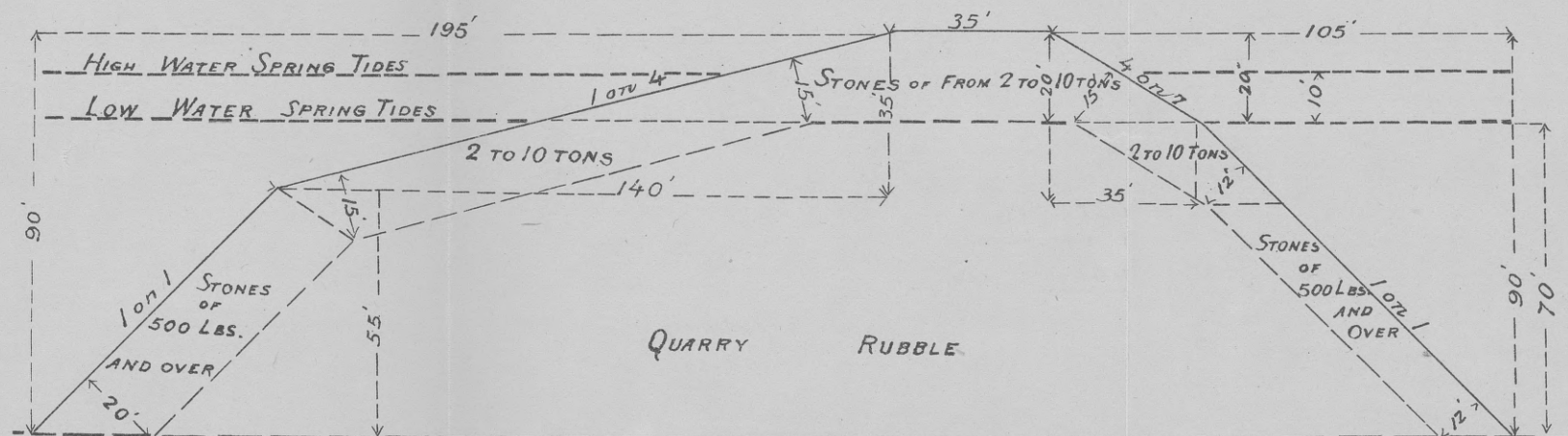
# —HARBOR OF REFUGE—

## —SECTIONS OF BREAKWATER—

AS PROJECTED  
— BY THE —  
BOARD OF ENGINEERS FOR THE PACIFIC COAST



AS PROJECTED  
— BY THE —  
MINORITY



SCALE - 1 INCH TO 40 FEET

S Ex 63 491

We have concluded our analysis of the Trinidad estimates. We think the conclusion is plainly enough indicated that the estimate of \$7,964,500, made by the Board in 1877, to cover 510 acres at Trinidad, is not very far out of the way, and that nothing but disappointment can follow the adoption of the opinion that a harbor can be made for any sum very much less.

The evidence before the Board bearing on the sea at Port Orford has already been analyzed. Basing our opinion on the evidence, we do not admit that Trinidad has a less sea because it is in a bight, nor that Port Orford has a heavier sea because it is near a salient. The effect of a bight is rather to concentrate and increase the sea. Nor do we admit the conclusion that the sea is heavier at Port Orford because the storms are heavier. The great swell that breaks on the coast is propagated from the distant ocean. Its effect in breaking depends more, in our judgment, on the formation and depth of the bottom than on local storms.

We therefore demur to any reasoning on facts of which we have knowledge which asserts a heavier profile to be necessary at Port Orford than at Trinidad.

Our judgment does not permit us to accept the line, southeast in direction, proposed by the minority for Port Orford, for the reason that the anchorage would be left almost as much exposed to the winter sea after the work was built as it is now. We very much prefer the location approved by the minority in 1877, which does not differ widely from our present line. A modification of the position proposed by us for Port Orford that we think can be entertained, is to move the line parallel or nearly parallel to itself, 200 yards, placing the work in 13 fathoms instead of 11. The increase in cost, if this modification should in the future be thought reasonable, is shown by the table immediately following of costs for different depths to be for the same length of breakwater 10 per cent. This change would add about 25 per cent. to the area protected.

COST OF BREAKWATER. BOARD'S SECTION AND PRICES PER LINEAR YARD.

Depth at mean low water:	Cost.
6 fathoms.....	\$4,904 91
7 fathoms.....	5,114 08
8 fathoms.....	5,334 50
9 fathoms.....	5,566 17
10 fathoms.....	5,809 56
11 fathoms.....	6,032 26
12 fathoms.....	6,328 49
13 fathoms.....	6,605 35
14 fathoms.....	6,893 09
15 fathoms.....	7,192 44

In concluding this review of the estimate of the minority report, we have felt obliged to cite a number of important points on which the minority has changed ground in the past three years. These changes are all in a direction to make the work at Port Orford more expensive, and that at Trinidad less expensive. The more important of these points are the direction of the sea at Trinidad and the supply of stone. The money value of these positions in their bearing on the cost of a work at Trinidad is something like \$4,000,000 or \$5,000,000.

In support of these new opinions, we have, for the first, some indefinite or contradictory statements of a few parties against a strong array of natural as well as personal evidence from unprejudiced persons. For the latter of the two propositions the minority report affords no support.

We also remark that if the minority report had, according to the usual course in such matters, been submitted at the time the majority report was prepared, these questions would have been discussed in the latter. The minority report was, however, not written for six weeks after that of the majority, and it is to that circumstance that the present discussion is due.

The minority considers that, with the line of breakwater projected by him, Trinidad would afford a capacious roadstead for naval rendezvous in time of war.

While believing that the minority's plan would furnish no adequate shelter at Trinidad, we do not think either it or Port Orford a proper point for occupation for that purpose. Both would necessarily be too contracted and too much exposed to attack by a maritime foe.

With long range heavy guns his fleet of war vessels, from a distance, were comparatively out of danger, could speedily and easily destroy all the costly establishments necessary for naval purposes. Either place could be fortified sufficiently to prevent an enemy from using the harbor, which is all that should be attempted.

#### GENERAL CONSIDERATIONS ON HARBORS OF REFUGE.

A harbor of refuge may be pictured in the mind as a capacious anchorage of smooth water, with an easy access in all weathers, resembling in these points some one of the natural harbors with which we may happen to be acquainted.

A harbor, such as can be made by the expenditure of any sum that has been estimated, at either Port Orford or at Trinidad, will not be of this character. It will in any case be contracted in its dimensions, and if the anchorage is made comparatively quiet, the quietness will be obtained at the expense of accessibility.

This will be apparent when we remember that the avenue by which vessels will enter is the same as that by which the swell will enter. Both will seek the harbor coming from a southwesterly direction.

As we make the entrance wider and more convenient for vessels, we at the same time favor the inset of the sea. If we shut out the sea in order to give smoother anchorage we lessen the accessibility. Moreover, it will probably be necessary, in order to provide routes for the circulation of the littoral current, so as to insure a maintenance of depth in the anchorage, to leave an opening for this purpose, as has been done in the project for Port Orford, and as would probably be necessary at any other point. This latter opening, if not arranged for use as a channel, could perhaps, owing to its small dimensions, be neglected as a disturbing cause in a consideration of the probable smoothness and security of the anchorage. Indeed, by permitting the escape of a wave without reflection from the shore, such an opening might be favorable to the tranquillity of the anchorage.

The area of fair anchorage depth, say over 5 fathoms, as provided for Trinidad in the project of the Board in 1877, is between 400 and 500 acres. The lines proposed for Trinidad by Professor Davidson cover about 500 acres, not all, however, by his own statement, fully protected.

The area at Port Orford, as now projected, is about 280 acres. It is not probable that any project covering much more area could be entertained at any of these points, owing to the increased cost. The area at Port Orford could, however, be increased at least 25 per cent. by placing the breakwater in 13 fathoms, at an additional cost of about 10 per cent.



The longest dimension of the anchorage ground in any of these harbors will be less than a mile.

Under these circumstances, we think it must remain doubtful, until proved by experience, whether the requisite smoothness of anchorage is consistent with an entrance width of a half mile, which is about the width that has generally been projected for the various harbors of refuge.

It seems to us plain that no greater facility of entrance to vessels than that thus provided can be expected, unless, indeed, the heaviness of the sea has been greatly overestimated.

Under this state of affairs as to the entrance, let us examine the question of accessibility during a southerly storm. The storm begins with the wind southeast, from which quarter it changes successively to south, south-southwest, and to southwest. In the closing phases of the storm the wind goes by the west to the northwest. A vessel to the windward would have the wind fair for the harbor during the strength of the gale. The weather, however, in these storms is thick, and the sea is always considerable and often very heavy.

Under this condition, a vessel to gain refuge must seek an opening one-half mile in width with a lee shore close abeam, within a quarter of a mile, if she happens to hit the channel in its axis. We have then a vessel deprived of all means of accurately determining her position running in a gale of wind and a heavy sea for a lee shore, where certain destruction impends if the narrow entrance is not reached. When we attempt to realize this picture in our minds, it seems that the dangers of the open sea must be very great indeed to induce a sailor to seek the certain dangers attending the search for shelter. The danger of stranding is the more imminent as the ship is larger and harder to handle and the master less acquainted with the shore. The danger, which amounts to prohibition in the case of sail vessels, is very much lessened to steamers.

We can now understand the very general opinion expressed by sailors, that in a gale they would prefer to keep the sea and not run for a harbor of refuge.

We are therefore inclined to the opinion that a harbor of refuge, such as is possible on the North Pacific coast, must be regarded as a refuge in a qualified sense. It can hardly, for any class of sail vessels, be a refuge accessible at all times. If it can be reached before the storm gains its force it will be truly a refuge, but if not so gained sail vessels must, as a rule, wait for the storm to pass before entrance.

We append to this report a chart of the coastwise commerce north of San Francisco, which represents all the commerce that can be thought to have any interest in this matter. This chart is a graphic representation, in a form easily grasped, of the relative commerce of each point on the coast for the year 1878.

It will be observed that out of a total of 1,683,362 tons, the Columbia River and points north, mainly the Strait of Juan de Fuca, take 1,215,341 tons—nearly three-fourths of the whole. Of the remaining fourth, nearly one-half—208,972 tons—are employed on the coast south of Cape Mendocino. Taking away from the total the sum of the fractions just mentioned, there remains a tonnage of 258,049, the sum of the traffic at all other points on the North Pacific coast. Of this latter sum, Humboldt Bay has rather more than one-half, and Coos Bay not quite one-third.

The changes that are in progress to disturb these ratios are a consid-



erable relative increase in the commerce of the more northern ports—the Columbia River and the Straits of Fuca. This fact is proved elsewhere in this report by statistics.

Another change in progress affecting the method of this commerce is unmistakable. That is, the substitution of steamers for sail vessels, except in the carrying of lumber. The general coast trade of the Columbia River is now almost entirely done by steamers. Since the date of the majority report, less than a year ago, arrangements have been made by building three steamers, of 3,000 tons each, at Chester, Pa., and by chartering two British ships, the Alnwick Castle and the Madeira, to add 12,000 or 13,000 tons of steam tonnage to the coal fleet to the Straits of Juan de Fuca. Allowing two trips a month to these steamers, there will be more than 300,000 tons additional steam tonnage to this fleet in a year.

This substitution of steam for sail on the north Pacific is merely following in the track of changes that have taken place elsewhere in all parts of the world.

We have, then, before us a view of the future coast commerce of the North Pacific, the northern portion of it outstripping the southern, and a conversion of the sailing fleet into a steam fleet, which will be strictly a coasting fleet running from headland to headland. How the channels of trade may be modified by the construction of the North Pacific Railway now in progress we do not attempt to predict.

San Francisco will, under any circumstances, remain the commercial center of our Pacific coast commerce. There must always be a large commerce between it and the northern coast, whatever changes may occur elsewhere.

We now call attention to the expressions of opinions laid before the Board in this matter of a harbor of refuge, in answer to its widely-published invitation, and, in some cases to personal solicitation, when there seemed to be an indisposition to express opinions. These opinions will be found in the appendixes to the former report, and we now refer to them for the purpose of generalizing, as far as may be, what may be considered as the feeling of the different fractions of the Pacific coast commerce into which we have subdivided the whole tonnage.

In regard to the southernmost fraction, namely, that trading south of Cape Mendocino, one-eighth of the whole coast commerce, we note the absence of any particular expression of a desire for a harbor of refuge, particularly for one north of Cape Mendocino. The claims of this fraction of commerce have been set forth in the minority report, and in some other papers submitted to the Board, in advocacy of Trinidad; but we have no reason to suppose that the views thus ably maintained are the views of the natural representatives of this commerce. Indeed, Messrs. Tichenor & Co., who have considerable interest in this commerce, express themselves as opposed to the construction of a harbor of refuge, but think if one is to be built it ought to be south of Cape Mendocino to be of any benefit to the southern fleet. The silence of other representatives of this interest, under the publicity of this investigation, may, perhaps, be regarded as an expression of indifference.

The attitude of the great fractions of the Columbia River and of the Straits of Fuca, representing nearly three-fourths of the coast commerce, cannot be regarded as one of interest in the subject, if we can judge from the opinions that have been laid before us by those who can fairly be called its representatives. The Columbia River interest is very much concerned to have the mouth of the river improved, so as to increase its accessibility and lessen the delays that occur, due to a want of sufficient





depth; but we observe no anxiety for shelter on the intervening coast. The same indifference characterizes the commerce to and from the Straits of Fuca.

As for foreign commerce proper, that is, the Trans Pacific commerce, it has not manifested the slightest interest in the matter.

We believe we are sustained, then, in the position that the fractions mentioned, making nearly seven-eighths of the coast commerce, are in an attitude of quiescent interest, if not of positive indifference, to a harbor of refuge.

The commercial friends, then, of this measure, must be looked for in the remaining fraction, rather more than one-eighth of the coast commerce. More than half of this is represented by Humboldt Bay; one-third belongs to Coos Bay; while the rivulets of trade to and from Trinidad, Crescent City, Port Orford, the Umpqua, and one or two other points, complete the fraction.

We are not aware that the Humboldt Bay interest has shown much concern in this matter. Trinidad would unquestionably be the most convenient of the points named for Humboldt Bay commerce if this commerce wants a harbor of refuge at all.

Coos Bay has manifested all the interest that could be expected of any place by the representations of all its industries; but this interest has not been general, but has been concentrated and conditioned upon the selection of Cape Gregory as a site, this point being close to the entrance to Coos Bay. We have, we believe, no evidence that Coos Bay wants a harbor of refuge at Port Orford or at Trinidad.

Crescent City representatives have been very active in laying the claims of that port before the Board, but Crescent City has spoken no word on the general subject, and appears indeed to be entirely indifferent, except in the case that the harbor shall be located at Crescent City.

So, while there is indifference in the greater part of the commercial marine, the part which favors a harbor is divided into as many factions as there are commercial ports.

From these generalizations it will appear that the commercial sentiment, as a whole, throws very little light upon the selection of a point for a harbor of refuge intended for the benefit of "general and local commerce," which are the terms used in the law directing this investigation.

In endeavoring to make a selection for this harbor we find ourselves in contact with mariners as a whole, indifferent or hostile, and with representatives of rival commercial points, each seeking the improvement of its own locality.

Taking in as best we can a general view of the commerce of the coast, as the signs of its development indicate its future, we have thought, and still think, that if the future commerce is to be benefited by a harbor of refuge, such a harbor must be placed in the track of this commerce, and on that part of the coast where it will be exposed to the greatest peril from prevailing storms.

To recapitulate, the majority thinks that in the foregoing report it has been shown:

That nearly all the large fleet of small coasters sails to points south of Mendocino City, half way to Trinidad and but 125 miles from San Francisco. That a harbor of refuge at Trinidad will not prevent disasters below Mendocino City or at outside ports just north of the latter place, nor would the bulk of the small coasters use it.

That the larger vessels in the local traffic to Humboldt Bay and Trinidad would use it, but that one placed at Port Orford would be available to them.

That the portion of the coast trade just considered is a constantly lessening fraction of the North Pacific commerce.

That nearly four-fifths of all the coast commerce would not use a harbor at Trinidad, but might be benefited more or less by one if put at Port Orford.

That the general commerce which might be thus benefited is constantly increasing.

That the main positions and objections urged by the minority against Port Orford as a site, and the special advantages claimed by him for Trinidad, have not been well taken.

The Board therefore, having examined and studied carefully the papers before it, and reconsidered the whole subject of the selection of a location for a harbor of refuge on the North Pacific coast, sees no reason for changing the views expressed in its report of March 6, 1880. On the contrary, the more thoroughly it investigates the subject the more firmly convinced it is of their soundness. In the words of that report:

According to the view held by the Board a harbor of refuge at Trinidad can never have the importance or produce the benefits to general commerce that are necessary to justify the expenditure of money required to build it.

If there is any place on the North Pacific coast where a large expenditure is justifiable it is at Port Orford.

The Board adheres to its former selection of Port Orford as the point most suitable for a harbor of refuge, the interests of commerce, local and general, being considered.

Respectfully submitted.

C. SEAFORTH STEWART,  
*Lieut. Col. of Engineers.*  
G. H. MENDELL,  
*Lieut. Col., Corps of Engineers.*  
G. L. GILLESPIE,  
*Major of Engineers.*

The CHIEF OF ENGINEERS, U. S. A.

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LETTER FROM LIEUTENANT-COLONEL R. S. WILLIAMSON, CORPS OF ENGINEERS.

SAN FRANCISCO, CAL., *February 1, 1881.*

SIR: I received yesterday afternoon from the senior member of the Board of Engineers for the Pacific Coast, a copy of a second report, dated January 15, 1881, on the subject of a harbor of refuge between San Francisco and the Straits of Fuca. After a full consideration of the subject, I find nothing to make me change my views previously expressed in my minority report, being fully convinced that if a harbor of refuge is to be made on the Pacific coast of the United States, and but one, Trinidad presents greater advantages for it than any other.

This recent report of the majority contains several statements which I would like to reply to, but as the majority wish to forward their report at once to the Chief of Engineers, I simply repeat my dissent at present, reserving to myself the right to present to you a full expression of my opinion at a later time.

Very respectfully, your obedient servant,

R. S. WILLIAMSON,  
*Lieut. Col., U. S. Engineers.*

The CHIEF OF ENGINEERS, U. S. A.